Psychosocial job stress
in relation to health

UNIVERSITEIT GENT

Faculty of Medicine and Health Science

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Psychosocial job stress in relation to health

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Thesis submitted in fulfilment of the requirements
for the degree of Doctor in Medical Sciences

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Psychosocial job stress in relation to health
PhD thesis Ghent University – with references – with summary in Dutch

The Belstress II study was financially supported by the Belgian Federal Public Service of Employment, Labour and Social Dialogue and by the European Social Fund.

Verschenen in de reeks monografieën van de Vakgroep Maatschappelijke Gezondheidkunde, Universiteit Gent

ISBN 9789078344056
D/2007/4531/2

Printed by DCL Print & Sign | Leegstraat 15 | 9060 Zelzate | www.dclsigns.be

“Pleasure in the job puts perfection in the work”

Aristotle (384 bc - 322 bc)

“Adopting the right attitude can convert a negative stress into a positive one”

Dr. Hans Selye (1907 - 1982)

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ABBREVIATIONS

BMI	Body mass index
BP	Blood pressure
CI	Confidence interval
CMV	Cytomegalovirus
CP	Chlamydia pneumoniae
CRP	C-reactive protein
CVD	Cardiovascular disease
ERI	Effort - reward imbalance
HP	Helicobacter pylori
HPA axis	Hypothalamic–pituitary–adrenal axis
JCQ	Job Content Questionnaire
(J)DC(S) model	(Job) Demand - Control (- Support) model
LBP	Low back pain
NIOSH	National Institute for Occupational Safety and Health
OR	Odds ratio
RR	Risk ratio
SAA	Serum amyloid A
SD	Standard deviation
T1	Time 1
T2	Time 2
WMC	World market competition

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Work-related health and well-being

Issues of work-related health and well-being have received growing attention during recent decades. More in particular, psychosocial work conditions, especially the perception of stress at work, has become a significant point of interest. There is increasing acceptance that a pure biomedical approach is not sufficient for understanding health; psychosocial conditions must also be taken into consideration (Levi, 2001). Health and well-being are prone to both physical and psychosocial influences.

Psychosocial well-being of workers has become an essential topic in social policy, both nationally and internationally. One of the formal objectives of the Belgian Federal Public Service of Employment, Labor and Social Dialogue is the improvement of working conditions. Within the unit for the humanisation of labor, a particular department is charged with the promotion of well-being at work (Algemene Directie Humanisering van de Arbeid, 2006).

In 1975, the European Foundation for the Improvement of Working and Living Conditions was set up by the European Council (Council Regulation (EEC) No. 1365/75) to contribute to the planning and design of better living and working conditions in Europe. The Foundation works in partnership with governments, employers, trade unions and the European Union institutions. One of its core areas of expertise is quality of work. A better quality of working life is central to the European Union's social policy agenda. An important focus lies in maintaining the health and well-being of workers. During the last decade, the Foundation has also been working on raising the awareness of stress as a workplace health issue (Houtman, 2005). The European Framework Directive on Health and Safety at Work (89/391/EEC) of 1989 involves an obligation for employers to "ensure the health and safety of workers in every aspect related to the work", and this mainly through the implementation of preventive measures. Psychosocial risks are covered by this Directive which is considered the keystone of the policy for the promotion of well-being at work.

In 1994, the European Agency for Safety and Health at Work was set up (Council Regulation (EC) No. 2062/94) with the mission to make Europe's workplaces safer, healthier and more productive, and in particular to promote an effective workplace prevention culture. The European Week for Safety and Health at Work in november 2002 (held in Bilbao, Spain) focused on the prevention of psychosocial risks and the stress they cause. It was concluded that psychosocial risks at work such as stress,

violence and bullying affect millions of workers in Europe with severe consequences in terms of both human costs (physical and psychological health effects) and economic costs (European Agency for Safety and Health at Work, 2003).
In the United States, the National Institute for Occupational Safety and Health (NIOSH) created by the Occupational Safety and Health Act in 1970 is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. It was established to help assure safe and healthy working conditions for working men and women. Stress at work constitutes an explicit research topic within NIOSH (NIOSH working group, 1999).

There are many divergent formulations regarding the conceptualization and measurement of stress (Kasl, 1996). Stress is a very broad concept with a diversity of meanings. Hans Selye, the originator of the biological concept of stress, generally described stress as reactions of the organism to several kinds of strain, challenges and demands from the environment (Levi, 1996). At the present time, stress is commonly conceptualized as mechanisms of individuals, who react - with their characteristic psychobiological program - to psychosocial stimuli (Levi, 2001). These mechanisms may lead to precursors of disease, or to disease and lack of well-being.
Within the epidemiological approach to stress, the emphasis is on an etiological orientation: stressors are classified as a class of risk factors or exposure variables that play a role in the etiology of a particular disease outcome (Kasl, 1996). A well-accepted conceptualization of work-related stress asserts that exposure to risk factors at work such as high work load or job insecurity, results in short-term stress reactions which may be emotional, cognitive, behavioral or physiological by nature (Houtman, 2005). When the exposure persists, there may also be long-term consequences for the individual (more permanent health outcomes). Individual characteristics influence the stress reactions.

The Job Demand - Control (- Support) model

The growing awareness of the importance of work-related well-being and stress has partly been the result of extensive research during the last decades on stress at the workplace and its consequences. Within this context, the introduction of Karasek's job strain model at the end of the seventies has been of major significance for occupational health research (Karasek, 1979; Karasek & Theorell, 1990). The model gave impetus

to the development of an extensive research tradition and has been the most influential model in studies on the impact of job stress on health and well-being during the past decades. The job strain model is a two-dimensional model that distinguishes two elements of the work environment: the job demands placed on the worker and the discretion the worker has in deciding how to meet these demands. According to the model, it is the combination of low decision latitude and heavy job demands which is associated with mental strain: “Psychological strain results not from a single aspect of the work environment, but from the joint effects of the demands of a work situation and the range of decision-making freedom available to the worker facing those demands.” (Karasek, 1979 – p. 287). Decision latitude or job control is composed of two concepts: skill discretion or the level of skill and creativity required on the job, and decision authority or the possibilities for workers to make decisions about their work.

Based on the combination of high versus low levels of the two components, four different kinds of psychosocial work experience are distinguished in the “Job Demand - Control” (JDC) model, as is depicted in the quadrant diagram in Figure 1. According to the strain hypothesis, the most adverse reactions of psychological strain occur when the psychological demands of the job are high and the worker’s decision latitude in the task is low, which is labeled as high strain jobs. Low average levels of psychological strain are predicted for situations with few psychological demands and high levels of control: low strain jobs. The learning hypothesis states that active jobs characterized by high levels of both job demands and decision latitude are expected to correlate with high degrees of learning and motivation. Passive jobs have low demand and low control, and are assumed to lead to negative learning and loss of work motivation. Active and passive jobs are correlated with average psychological strain according to the model.

The first empirical tests of the JDC model were performed with national data from surveys in the United States and Sweden (Karasek, 1979; Karasek & Theorell, 1990). The general job strain hypothesis was supported for a variety of mental strain symptoms and for heart disease. Empirical evidence was also found for the active learning hypothesis.

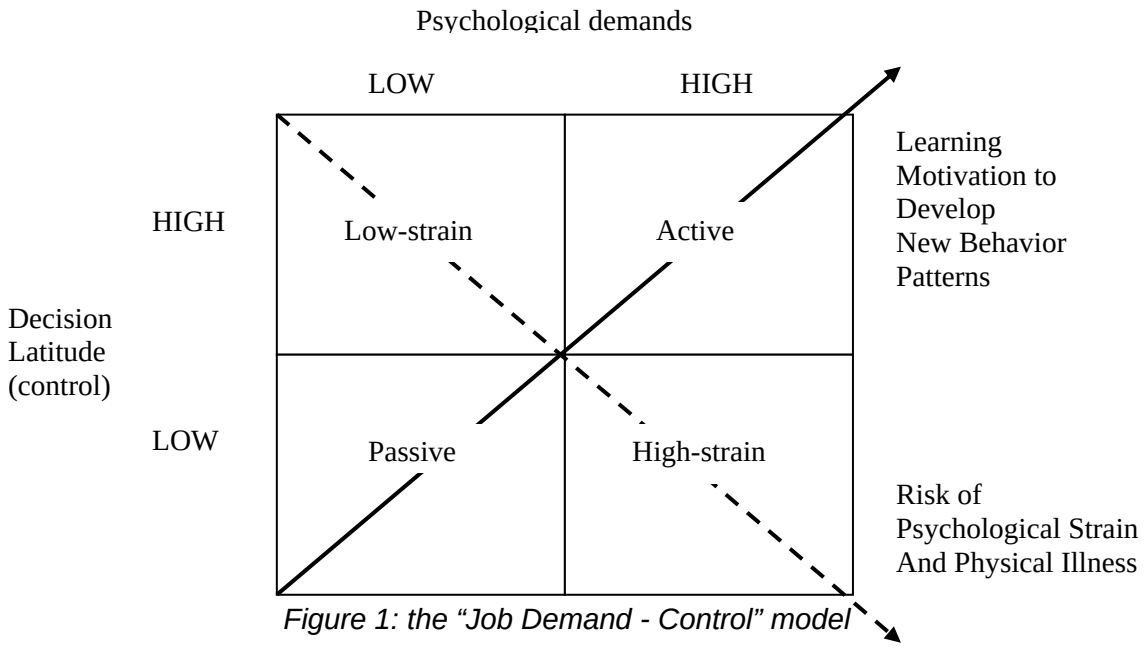

Figure 1: the "Job Demand - Control" model

In a later phase, the original JDC model was extended to include social support at the workplace by supervisors and co-workers as a third dimension: the "Job Demand - Control - Support" (JDCS) model (Johnson & Hall, 1988). The 'iso-strain' hypothesis states that workers with high job strain in combination with low social support at work, labeled as 'iso-strain' or 'isolated strain', are most vulnerable to negative health effects.
For the purpose of empirically testing the JDCS model, the Job Content Questionnaire (JCQ) was developed as a self-administered instrument with standardized questions that measure elements of the psychosocial work environment (Karasek, 1985; Karasek *et al*, 1998). In the full recommended version of the instrument, the scale of psychological job demands or mental workload is defined by five items: 'work fast', 'work hard', 'excessive work', 'conflicting demands' and 'insufficient time to work'. Decision latitude or job control is composed of two subscales: skill discretion, measured by six items ('keep learning new things', 'can develop skills', 'job requires skills', 'task variety', 'repetitive work' and 'job requires creativity') and decision authority, measured by three items ('have freedom to make decisions', 'choose how to perform work' and 'have a lot of say on the job'). The scale of social support at work also consists of two subscales: supervisor support, measured by four items ('supervisor is concerned', 'supervisor pays attention', 'helpful supervisor' and 'supervisor is good organizer') and co-worker support, measured by four items ('co-workers are competent', 'co-workers have interest in me', 'friendly co-workers' and 'co-workers are helpful'). All JCQ items are scored on a 4 point - Likert scale ranging from "totally

disagree" to "totally agree". The JCQ has been widely used in large studies in the United States, Canada, Europe and Japan. The instrument has been translated into over 22 languages. The relatively short length and high predictive validity appear to be the major reasons for its success.

Numerous studies have used the JDC(S) model to examine associations between psychosocial elements of the work environment and health outcomes. The largest part of the empirical testing of the model is situated in the field of cardiovascular disease. Wide consensus exists on the causal role of some classical risk factors for cardiovascular disease, dealing with personal characteristics (such as age, sex and family history), biochemical or physiological factors (such as elevated blood pressure and cholesterol) and lifestyles (including smoking behavior, alcohol consumption, physical activity and diet high in saturated fat) (De Backer *et al*, 2003). However, these individual and behavioral factors are not sufficient to explain the variance in risk patterns for cardiovascular disease. In order to have an improved understanding of the development of cardiovascular disease, we ought to look further than the isolated individual and add social environmental factors as well (Schnall *et al*, 2000). There is a growing body of evidence linking psychosocial factors to coronary heart disease, with job strain as a major issue of attention (Schnall *et al*, 1994; Hemingway & Marmot, 1999; Steptoe, 1999; Belkic *et al*, 2000; Belkic *et al*, 2004; Strike & Steptoe, 2004).

Objectives

The general aim of this thesis was to study the perception of psychosocial job stress, based on the JDCS model, in relation to health within the longitudinal Belstress study.

BELSTRESS, the Belgian part of the European JACE study, was a large epidemiological cohort study about job stress, cardiovascular and other health issues and sickness absence (Coetsier *et al*, 1996; Houtman *et al*, 1999). The first phase of the study took place from 1994 to 1998. A total of 21,419 respondents (16,329 men and 5,090 women) from 25 companies or public administrations across Belgium were involved. Within the participating companies or administrations, all workers aged 35-59 years were personally invited for the study. A participation rate of 48% was reached. Data were gathered through self-administered questionnaires and bio-clinical examinations. The questionnaires contained information on work-related characteristics

(including psychosocial factors from the JDCS model), sociodemographic characteristics, lifestyle factors, medical history, health perception and mental health. In collaboration with the occupational health services of the companies, trained observers conducted the medical examinations which aimed mainly at measuring classical coronary risk factors (such as blood pressure, cholesterol and body mass index).

Based on the cross-sectional data from the Belstress study, results were published relating to the scale reliability and validity of the JDCS model (Pelfrene *et al*, 2001; Pelfrene *et al*, 2003a), and regarding associations of psychosocial job stress with coronary risk factors (Pelfrene *et al*, 2002a; Pelfrene *et al*, 2003b), as well as with psychological well-being (Pelfrene *et al*, 2002b; Pelfrene *et al*, 2004). Registered data on sick leave of the majority of the respondents during 12 months following the questionnaire date were obtained from the companies and linked to job stress measures at baseline (Moreau *et al*, 2004). In addition, perceived job stress in the Belstress study was related to the short-term incidence of coronary events in the majority of the male population: a total of 14,337 men were followed up for coronary events during 3 years (De Bacquer *et al*, 2005).

A few years after the first phase of the Belstress study was completed, it was decided to proceed with a continuation of the study: Belstress II. The five formal objectives of the study were:

1. Study of the dynamics of psychosocial factors and the relation with health outcomes
2. Study of the relation between psychosocial factors and musculoskeletal symptoms
3. Study of the relation between psychosocial job stress and arterial blood pressure
4. Study of gender differences in the relation between the dynamics of psychosocial factors and health outcomes
5. Study of the relation between obesity and the perception of job stress

The second study phase took place from 2002 to 2004 and involved nine of the original 25 companies or public administrations. All workers who had participated in the first study and who were still at work in the same companies, were invited to participate again. A total of 2,821 persons (1,950 men and 871 women) participated, which was 67.2% of the eligible population. Data were gathered for a second time through self-administered questionnaires and bio-clinical examinations.

Financial support for the study was obtained from the Belgian Federal Public Service of Employment, Labour and Social Dialogue and from the European Social Fund. It was a multi-center study and was carried out by the School of Public Health of the Free University of Brussels and by the Department of Public Health of Ghent University. The study was approved by the ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels.

The work presented in this thesis is primarily based on the second phase of the Belstress study, although it evidently builds upon the first study. The thesis can be seen as a progression toward prior findings of the Belstress project in two ways. First, the availability of a second measurement of the data allowed conducting longitudinal analyses. Secondly, some refinements were made in studying possible explanatory variables in the job stress – coronary heart disease link.

As mentioned before, the general aim of this thesis was to study the perception of psychosocial job stress in relation to health within the longitudinal Belstress study. There were three more particular objectives. The first objective was to examine long-term changes in the perception of job characteristics. Within the longitudinal Belstress study, 2,821 workers completed the JCQ on two separate occasions with a mean time interval of 6.6 years. This allowed us to explore the particular nature and extent of long-term intra-individual changes in psychosocial job characteristics. Over the last decade, the labor market in Western societies has undergone profound changes characterized by globalization of economic relations, increased flexibility of the job market, an increasing number of precarious jobs and high levels of job insecurity (Marmot, 1999; Benach *et al*, 2000; Goudswaard & Andries, 2000). Our purpose was to find out whether the longitudinal Belstress data were in accordance with these trends. An additional aim was to explore whether or not there was a statistically significant long-term stability of the JCQ scales. For this first objective of the thesis, we refer to the paper in the first chapter: "**Long-term Changes in the Perception of Job Characteristics: Results from the Belstress II – Study**".

The second objective was to explore some possible explanatory mechanisms in the alleged relation between job stress and coronary heart disease. There is considerable support for the association between psychosocial work factors and coronary heart disease (Schnall *et al*, 1994; Belkic *et al*, 2000; Belkic *et al*, 2004). Within the 3-year

follow-up of coronary events in the male population of the first Belstress study, a non-significant 38% risk excess was found among workers with high job strain after adjustment for covariates; low social support at work was associated with a substantially and significantly elevated risk (De Bacquer *et al*, 2005). According to a recent systematic review and meta-analysis of prospective cohort studies, work stress was associated with about a 50% excess risk of coronary heart disease (Kivimaki *et al*, 2006b). When exploring potential mediating mechanisms in the association between psychosocial work factors and coronary heart disease, strongest empirical evidence is found for elevated blood pressure (BP). Nonetheless, there is only limited evidence for the association between components of job stress and casual measurements of BP, while more consistent results were found for ambulatory BP measurements. Within the first phase of the Belstress study, no consistent associations were found between job strain and casual measures of BP (Pelfrene *et al*, 2002a). Our aim was to assess the relation between high job strain and ambulatory BP measurements; this was studied in a subsample of the Belstress II population. This issue is addressed in the second chapter: "**High Job Strain and Ambulatory Blood Pressure in Middle-Aged Men and Women from the Belgian Job Stress Study**".

On the whole, classical coronary risk factors such as elevated BP, cholesterol and smoking, are not sufficient to explain the association between job stress and coronary heart disease (Schnall *et al*, 1994; Hemingway & Marmot, 1999; Belkic *et al*, 2000). Job stress measures have not always been consistently linked to these factors. Furthermore, in many studies the positive association between job stress and coronary heart disease did not disappear after controlling for classical risk factors. Therefore, alternative pathways have been explored. Given that there is growing evidence for the predictive value of biomarkers of inflammation (Danesh *et al*, 2000a) and, to a lesser extent, of infectious parameters (Danesh *et al*, 2000b) regarding cardiovascular disease, these mechanisms have been put forward as possible intermediate variables linking job stress to elevated risk of cardiovascular disease. We examined the cross-sectional association between job stress measures and biomarkers of inflammation and infection in a subsample of the Belstress I population. This study is presented in the third chapter: "**Associations Between Dimensions of Job Stress and Biomarkers of Inflammation and Infection**".

The third objective of the thesis was to examine the role of psychosocial job stress in some health outcomes other than cardiovascular disease with longitudinal data from

the Belstress study. Although the largest part of the empirical testing of the JDC model has been situated in the field of cardiovascular disease, the model has also found support in relation to other topics. Musculoskeletal complaints constitute an important focus in occupational health research. Several biomechanical and physical factors from the work environment are considered established risk factors for low back pain (LBP) (Punnett & Wegman, 2004). There is growing consensus that in addition to individual and physical risks, psychosocial work characteristics play a role in LBP, although results are not consistent across studies (Davis & Heaney, 2000; Hartvigsen *et al*, 2004). Within the longitudinal Belstress study, we described the impact of psychosocial factors, both work- and nonwork-related, on the prevalence of LBP. This study is described in the fourth chapter: "**The Impact of Psychosocial Factors on Low Back Pain – Longitudinal Results from the Belstress Study**".

In the first implementation of the JDC model, the job strain hypothesis was supported for a variety of mental strain symptoms (Karasek, 1979; Karasek & Theorell, 1990). Numerous studies have examined associations between job strain and psychological well-being, but results are not consistent across studies (Van Der Doef & Maes, 1999). Support for an association is mainly found in cross-sectional studies, while longitudinal studies are rather scarce and provide less support. Results in prospective studies are usually based upon a single assessment of job stress. Within the first phase of the Belstress study, several aspects of psychological well-being were cross-sectionally associated with job stress (Pelfrene *et al*, 2002b; Pelfrene *et al*, 2004). We examined the prospective relation between perceived job stress and depression symptoms with longitudinal data from the Belstress study. In addition, the impact of repeated job strain was explored. For this study we refer to the fifth chapter: "**Job Stress and Depression Symptoms in Middle-Aged Workers – Prospective Results from the Belstress Study**".

CHAPTER 1

Long-Term Changes in the Perception of Job Characteristics: Results from the Belstress II—Study

Els CLAYS, Dirk De BACQUER, Françoise LEYNEN, Marcel KORNITZER, France KITTEL and Guy De BACKER

Journal of Occupational Health **2006; Vol. 48: 339-346**

Abstract

The aim was to explore long-term changes in the perception of job characteristics—based on the Job Content Questionnaire (JCQ)—in view of the changing labor market in Western societies. A total number of 2,821 workers from nine companies were involved in the longitudinal Belstress-project. Data were gathered on two occasions with a mean time interval of 6.6 years. At both times, participants completed the JCQ which measures the perception of job demands, job control and social support. In addition, the instrument contains questions regarding physical job demands, job insecurity and impact of world market competition (WMC). Changes over time in the perception of the different dimensions of the JCQ were evaluated within a sample of 2,490 respondents who remained in the same job. A statistically significant long-term stability of all JCQ scales was found. As far as intra-individual changes over time are concerned, the population showed a modest average increase in the perception of job demands, control and support of approximately 3%. Long-term changes in the other scales were larger, with an average increase of 10.3% in job insecurity and 15.5% in impact of WMC. Substantial variation in these two scales was found at the level of the company and in some socio-demographic factors. While perceived job characteristics remained relatively stable over an average period of 6.6 years, a substantial increase was noted in job insecurity and the impact of WMC. These dimensions are becoming increasingly important within the context of economic globalization and labor market flexibility.

Introduction

For many years, work-related psychosocial factors have been considered to have important implications for health conditions. The perception of stress at work has been extensively studied and related to health outcomes. Many of these studies were situated in the field of cardiovascular health (Belkic *et al*, 2004), but associations have also been demonstrated with respect to mental health (Van Der Doef & Maes, 1999), musculoskeletal disorders (Hoogendoorn *et al*, 2000) and sick leave (Moreau *et al*, 2004).

One of the most influential and widely used models in this field is the Job Demand - Control (- Support) (JDCS) model, introduced by Karasek in the seventies (Karasek, 1979; Karasek *et al*, 1998). According to this model, the most adverse health effects are expected when workers are exposed to high psychological demands in combination with low decision latitude or job control, which is labeled as 'high job strain'. At a later date, the model was extended to a third dimension, social support at the workplace by supervisors and co-workers (Johnson & Hall, 1988). The 'iso-strain' hypothesis states that people with high strain and low social support, labeled as 'isolated strain', are most vulnerable to negative health effects. The Job Content Questionnaire (JCQ), a self-administered instrument, was designed to measure psychosocial job characteristics in a standardized way (Karasek, 1985). The instrument also contains a measure of physical demands of the job, because the 'demanding' aspects of work relate to both mental and physical loads. In addition, the instrument was supplemented with items assessing the perception of job security and the impact of world market competition (WMC) on perceptions of demands, control and job security. Validity and reliability of different versions of the JCQ have been demonstrated in several studies (Kawakami *et al*, 1995; Brisson *et al*, 1998; Karasek *et al*, 1998; Pelfrene *et al*, 2001; Niedhammer, 2002). The attractiveness and broad international usage of the instrument is attributed to its simple use, short length and predictive validity.

This study addressed the issue of long-term changes in the perception of the different dimensions of the JCQ over an average interval of 6.6 years in people who remained in the same job. The first objective of this study was to find out whether or not there is a statistically significant long-term stability of the JCQ scales. Long-term stability was examined for the three core dimensions of the job strain model—job demands, job control and social support—in addition to the supplementary scales of physical

demands of the job, job insecurity and impact of WMC. Our hypothesis was that the job characteristics scales are significantly stable over a 6.6 year time interval, as in previous studies which have reported the stability of the scales over periods of five years (Kayaba *et al*, 2005) and four years (Cheng *et al*, 2000). The second objective was to explore the particular nature and extent of intra-individual changes in job characteristic scales over a period of 6.6 years on average. In view of increased globalization and flexibility of labor markets in Western societies over the last decade (Marmot, 1999; Benach *et al*, 2000; Goudswaard & Andries, 2000), it was hypothesized that perceptions of job characteristics would be influenced by these trends. We especially expected the perceptions of job insecurity and the impact of WMC to have increased since these scales were added to the JCQ, in order to respond to the rapidly increasing importance of factors at the organization, especially, global economy level contributing to increased demands, job insecurity and lack of control (Karasek, 1985).

Methods

Study population

Long-term evolutions in the perception of the different dimensions of the JCQ were explored using data from the Belstress-project, a large epidemiological cohort study about job stress, cardiovascular and other health issues and sickness absence. Belstress is the Belgian part of the European JACE study (Houtman *et al*, 1999). Between 1994 and 1998, a total of 21,419 respondents, aged 35–59 years, from 25 large companies or public administrations across Belgium were involved in the first phase of the study. Although this population cannot be considered representative of the Belgian workforce, it is fair to assume that the sample contains substantial variation in exposure to job stress.

In 2002–2003, some companies with whom good cooperation had been achieved in the first study phase were selected for participation in Belstress II. Nine of the original 25 companies or public administrations were involved. Within these companies, all persons who had participated in Belstress I and who were still at work, were invited to participate in the second phase. Overall, 52% of the original population was no longer available for participation due to decease, chronic disease, retirement, resignation or dismissal. Within three companies from the secondary or manufacturing sector, major reorganizations and restructuring measures had been carried out, as a result of which,

73% of the original study sample was no longer at work at the follow-up. Some important reorganizations had also taken place within four companies from the service sector; 47% of the population was no longer eligible for participation. Within two public administrations, 33% was no longer eligible, which was mostly due to natural retirement. A total number of 2,821 participants remained which was 67.2% of the eligible population. In both phases of the study—Time 1 (T1) and Time 2 (T2)—respondents were classified into occupational groups according to the first digit of the International Standard Classification of Occupations (ILO, 1990). Results presented here are based on observations in 2,490 participants who did not change jobs during the interval between T1 and T2. Since the aim of this study was to explore changes in the perception of the work environment, we wanted to rule out changes that were due to objective changes in job title.

The Belstress study was approved by the ethics committees of the University Hospitals of Ghent (UZ) and Brussels (Erasmus).

Job characteristics scales

In both phases of the study, participants completed a self-administered questionnaire containing the recommended version of the JCQ (Karasek, 1985). Psychological job demands were measured by five items that relate to mental work load, organization constraints on task completion and conflicting demands. Job control or decision latitude was composed of two subscales: 'skill discretion', or the level of skill and creativity required on the job (six items), and 'decision authority', or the possibilities for workers to make decisions about their work (three items). The dimension of social support at the workplace also consisted of two subscales: 'supervisor support' (four items) and 'co-worker support' (four items). In case of one missing value per (sub)scale concerning the dimensions of demands, control and support, the mean value which was calculated over the set of remaining valid (sub)scale-items for that particular respondent was imputed, picking up 5% more valid cases at most.

Beside the three core dimensions of the job strain model, the JCQ instrument contains some additional scales (Karasek, 1985). The scale of physical demands contained five items on physical exertion, static and dynamic physical loads. Perception of job insecurity was measured with two questions, evaluating the respondent's assessment of his or her present and future situation regarding job security. Impact of WMC was measured by three items that relate to the threat or the impact of competition from

world trade on the respondent's perception of job security, work pace and influence over the way things are organized at the workplace.
All JCQ items have four response categories ranging from 'fully agree' to 'fully disagree', except for the item concerning future job insecurity which has outcome categories ranging from 'very unlikely' to 'very likely'.

Statistical analyses

Cross-time stability in the perception of the different JCQ scales was assessed with non-parametric Spearman rank correlation coefficients, which are based on the ranking of data. Kappa coefficients were calculated as a measure of agreement between classification at T1 and T2 into high and low levels of the JCQ scales. For the purpose of examining the nature and extent of changes over time in the perception of job characteristics, differences between the scores at the first and second data collection were computed. Whether the average differences were significantly different from zero were tested by means of Paired-Samples t tests. Besides the differences in absolute values, proportional changes in the scores were calculated [((T2 –T1) / T1)* 100]. General distributions of these percentage evolutions were considered, with the Komogorov-Smirnov test to assess normality. In analyses of variance, mean percentage changes in the scores were compared between categories of gender, age, educational level, occupational class and company. In case of more than two categories, Scheffé post hoc tests were conducted in order to make pairwise comparisons of the factor level means.
All statistical analyses were performed using SPSS 10.0 software.

Results

Perceptions of the JCQ dimensions were measured on two occasions in a sample of 2,490 workers with stable job titles. The time interval between the first and second phase of the study ranged from four to eight years; the mean interval was 6.6 years (SD 1.13). The majority of the population (67%) was male. The sample contained 17.2% executives, 47.1% white-collars and 35.7% blue-collar workers. Participants were aged 40–64 years at the second phase; the mean age was 50 years (SD 4.88).

Table 1.1 shows basic characteristics of the JCQ scales. Internal consistency of the scales at both times of datagathering was good or acceptable, with Cronbach's alpha's ranging from 0.70 to 0.89.

Table 1.1 Basic characteristics of the job characteristics scales (n = 2,490)

	Number of items	T1			T2		
		Mean (SD)	Range	Cronbach alpha	Mean (SD)	Range	Cronbach alpha
Psychological job demands	5	30.5 (6.4)	12 – 48	0.73	30.6 (6.1)	12 – 48	0.71
Job control	9	68.3 (12.0)	26 – 96	0.82	69.2 (11.4)	24 – 96	0.81
Social support at work	8	22.6 (3.7)	8 – 32	0.84	22.9 (3.5)	8 – 32	0.82
Physical job demands	5	9.5 (3.4)	5 – 20	0.87	9.5 (3.3)	5 – 20	0.85
Job insecurity	2	3.4 (1.3)	2 – 8	0.70	3.5 (1.4)	2 – 8	0.70
Impact of WMC	3	6.0 (2.5)	3 – 12	0.89	6.4 (2.4)	3 – 12	0.87

WMC=world market competition

The extent of changes over time in the perception of the JCQ dimensions is shown in Table 1.2. Cross-time correlations were highly significant for all scales, although substantial differences existed in the strength of correlation. High correlation between the two measurements was found in the scales of physical job demands and impact of WMC, while the scale of social support at the workplace had a weak cross-time correlation.

At both observation times participants were classified into high and low levels regarding the six JCQ dimensions, based on the median-split procedure. When considering the proportion of participants staying in the same category (high or low) at T2 as compared to T1, a similar pattern regarding long-term changes emerged: the percentage staying in the same category and the corresponding kappa coefficient were high with respect to the impact of WMC, physical demands of the job and job control, while the Kappa coefficient was only moderate with respect to social support, job demands and job insecurity.

In order to explore the extent and nature of long-term changes in the perception of job characteristics in more detail, Paired-Samples t tests were conducted and percentage changes in the JCQ scales were calculated. Scores in all six scales increased on average but without statistically significance for psychological and physical demands of

the job. Long-term proportional changes in the three core scales of the job strain model—demands, control and support—as well as in physical job demands, followed a fairly regular and uniform pattern. The percentage changes were not excessively large and according to Komogorov-Smirnov tests a more or less normal distribution was approached. On average, the population showed a modest increase in the scores of approximately 3%. This rather normal and regular distribution of evolutions was especially true for the job control scale. In contrast, the patterns of long-term evolutions in perception of job insecurity and WMC were rather irregular; they were less normally distributed and showed more excessive changes. On average, the sample was characterized by a substantial increase in job insecurity (10.3%) and impact of WMC (15.5%).

Table 1.2 Changes over time in the perception of the job characteristics scales (n = 2,490)

	Spearman cross-time correlation	% in same category – [kappa coefficient]	Mean difference T2 – T1	Mean % change (SD)	CI mean % change
Psychological job demands	0.50***	68 – [0.36]	0.10	2.8 (22.5)	(1.9 ; 3.7)
Job control	0.60***	74 – [0.47]	0.87[a]	3.0 (18.3)	(2.3 ; 3.8)
Social support at work	0.38***	65 – [0.29]	0.36[a]	3.7 (20.5)	(2.9 ; 4.5)
Physical job demands	0.72***	79 – [0.57]	0.03	4.3 (29.0)	(3.2 ; 5.5)
Job insecurity	0.48***	70 – [0.39]	0.11[a]	10.3 (46.3)	(8.5 ; 12.1)
Impact of WMC	0.67***	79 – [0.57]	0.39[a]	15.5 (46.1)	(13.7 ; 17.3)

CI=95% Confidence Interval; WMC=world market competition; *** p<0.001; [a] Paired Samples t test p<0.001

We also examined whether changes in the perception of the JCQ dimensions differed in relation to sociodemographic and environmental factors (Table 1.3). Apart from physical job demands, there was significant variation in the long-term changes of the scales between the different companies, irrespective of age, gender, educational level and job title. This difference at the company level was most manifest with respect to changes in job insecurity and the impact of WMC.

The percentage increase of the six job characteristics scales was rather homogeneous across age and educational level (with the exception of job insecurity), and occupation

(with the exception of impact of WMC). Gender differences were more pronounced with less increase of psychological job demands in men and less increase of social support in women, who showed a slight decrease in perception of job insecurity.

Table 1.3 Changes in the perception of job characteristics scales in relation to sociodemographic and environmental factors (n = 2,490)

	% changes											
	Psychological job demands		Job control		Social support at work		Physical job demands		Job insecurity		Impact of WMC	
	Mean	*P*[a]	Mean	*P*[a]	Mean	*P*[a]	Mean	*P*[a]	Mean	*P*[a]	Mean	*P*[a]
Gender		0.03		0.29		0.02		0.38		0.00		0.63
Men	2.0		2.8		4.1		4.1		16.1		15.8	
Women	4.6		3.5		2.6		4.9		- 1.8		14.9	
Age		0.12		0.08		0.71		0.50		0.00		0.25
40-49	3.2		4.0		3.7		4.8		11.2		16.3	
50-64	2.5		2.2		3.6		4.0		9.5		14.9	
Educational level		0.99		0.94		0.30		0.47		0.02		0.99
Higher	0.9		1.8		3.1		5.6		16.1		10.5	
Middle	3.2		3.5		5.0		3.6		4.5	[b]	15.0	
Lower	4.0		3.6		3.1		3.9		10.7		20.1	
Occupation		0.51		0.10		0.06		0.21		0.29		0.00
Executives	- 0.5		0.2		2.2		4.9		19.3		9.0	
White-collars	2.7		3.7		4.7		5.3		4.7		12.4	
Blue-collars	4.6		3.5		3.0		2.8		13.4		23.3	[b]

WMC=world market competition; [a] Multivariate: adjusted for other factors in the table and additionally for company; [b] p<0.001 (results Scheffé Post Hoc tests: significance of difference from first category)

For the analyses presented here, workers whose job title changed between T1 and T2 were excluded. In Table 1.4, mean JCQ scores at baseline are compared between workers who stayed in the same job (2,490 participants) and workers whose job title changed from T1 to T2 (331 participants). The subgroup with job changes showed significantly higher mean job demands scores, independent of age, gender and educational level. When long-term changes in JCQ dimensions were explored within this subgroup with changing jobs, a distinct pattern emerged (results not shown in table). Cross-time correlations for all JCQ scales were still statistically significant, but Spearman correlation coefficients were somewhat weaker with respect to psychological job demands (0.45), job control (0.58), social support at work (0.34) and physical job demands (0.67). An important difference was found regarding the long-term change in physical job demands: no slight increase was established in those whose job title changed (the average increase was only 0.5%, SD 29.1); moreover, a statistically significant mean difference in T2–T1 scores of –0.47 was found according to the Paired-Samples t test (P<0.01). Also notable was the distinct pattern for change in job control perception: a larger average increase of 5.2% (SD 21.4) was found within the subgroup with changing job title, as well as a higher mean difference in T2–T1 scores of 2.26 (P<0.001). In addition, those whose job title changed had a smaller average increase in psychological job demands of 1.7% (SD 26.0) and a somewhat larger average increase in social support at work of 5.0% (SD 18.9).

Table 1.4 Comparison of job characteristics scales at baseline between workers who stayed in the same job (n = 2,490) and workers whose job title changed (n = 331)

	N = 2,490 Mean (SD)	N = 331 Mean (SD)	P^a
Psychological job demands	30.5 (6.4)	32.2 (6.7)	0.00
Job control	68.3 (12.0)	70.4 (12.2)	0.28
Social support at work	22.6 (3.7)	22.6 (3.3)	0.83
Physical job demands	9.5 (3.4)	9.2 (3.5)	0.99
Job insecurity	3.4 (1.3)	3.5 (1.3)	0.29
Impact of WMC	6.0 (2.5)	6.5 (2.5)	0.12

WMC=world market competition; [a] adjusted for age, gender and educational level

Discussion

Main findings

The aim of this study was to explore long-term changes in the perception of the different dimensions of the JCQ over an average interval of 6.6 years, in a population of 2,490 participants who remained in the same job. A statistically significant long-term stability of all JCQ scales was found. As far as the nature and extent of intra-individual changes over time is concerned, the perception of psychological and physical job demands, job control and social support remained relatively stable over the average period of 6.6 years, while a substantial increase was noted in feelings of job insecurity and impact of WMC.

Several studies have highlighted the importance of assessing cumulative working life exposure to job stress rather than measuring job characteristics at only one point in time, since this reduces the risk of misclassifications due to inaccuracy in assessments (Johnson & Stewart, 1993; Johnson *et al*, 1996; Amick *et al*, 2002; de Lange *et al*, 2002; Landsbergis *et al*, 2002; Landsbergis *et al*, 2003a). In some studies, short-term stability of job characteristics scales has been demonstrated with cross-time (one year) correlation coefficients for job demands ranging from 0.64 to 0.68, and for decision latitude ranging from 0.64 to 0.76 (Carayon, 1993; Brisson *et al*, 1998; Landsbergis *et al*, 2000). Cross-time correlation coefficients in our population were lower compared to these, but were still highly significant. Stability over time was clearly highest when it concerned perceptions of rather objective aspects of the workplace, such as physical load and globalization in the organization. Overall, our findings regarding the long-term stability of job characteristics scales were comparable to the results of two other studies. A statistically significant five-year stability of job characteristics scale scores was shown in a population of 458 Japanese community workers, with moderate intra-class correlation coefficients for the decision latitude scores (0.63) and the job demands scores (0.55) (Kayaba *et al*, 2005). Similar findings were also reported within an American cohort study including 21,290 female nurses: correlation coefficients over a four year period were 0.60 for job control, 0.54 for job demands and 0.41 for social support (Cheng *et al*, 2000). In addition, in developing a Work History Questionnaire, Landsbergis *et al* (2002) discovered that retrospective assessment of job demands and job decision latitude using scales with a limited number of items had a moderate correlation with longer JCQ scales when assessing the same job at later dates, while

the assessment of workplace social support was more weakly correlated with the JCQ scales. These studies however provided no, or only little, information on the exact nature and extent of long-term changes in the perception of job characteristics as measured by the JCQ, especially with respect to the supplementary scales regarding job insecurity and the impact of WMC.

Within our population, a modest average increase in the perception of psychological and physical job demands, job control and social support at work of approximately 3% was noticeable. The percentage changes in these scales, and most of all in job control, were not excessive and approached more or less a normal distribution. On the whole, these results are in line with findings from the Third European Survey on Working Conditions in 2000: between 1995 and 2000, a relative stabilization was found for job control and support from colleagues, as well as a minor intensification of work and a slight deterioration in physical demands (Paoli & Merllié, 2000). The core JCQ scales showed some notable responsiveness to change since the cross-time correlation coefficients were weaker for those whose job title had changed at the follow-up. Also, a distinct pattern of intra-individual changes in these scales was found in the subgroup, with a smaller average percentage increase in psychological and physical job demands, and a larger average percentage increase in job control and social support at work. Weaker correlations between baseline and follow-up scores of psychological job demands and job control among workers who experienced job changes, as well as a notable increase in job control levels in this group, were also found in the Japanese five-year follow-up study (Kayaba *et al*, 2005).

Long-term evolutions in the perception of job insecurity and the impact of WMC followed a rather irregular pattern with more excessive changes. The sample was characterized by a substantial mean increase in job insecurity of 10% and in the impact of WMC of 15.5%. Karasek added these two scales to the JCQ instrument because of the rapidly increasing importance of factors at the organization and, especially, global economy level (Karasek, 1985). Over the last decade, the labor market in Western societies has indeed undergone profound changes characterized by globalization of economic relations, increased flexibility of the job market, an increasing number of precarious jobs and high levels of job insecurity (Marmot, 1999; Benach *et al*, 2000; Goudswaard & Andries, 2000). These trends are reflected in our results: although perceptions of job characteristics only changed in minor ways over an average period of 6.6 years, changes in perceptions regarding factors at organizational and global economic levels were less uniform and more pronounced.

Most likely the observed changes in the perceptions were not attributable to the ageing of the participants, since no cross-sectional associations were found between age and the different JCQ scales in our population. One exception to this however is the perception of job insecurity, which was negatively related to age. Therefore the observed increase in the perception of job insecurity was probably underestimated.
We found considerable variation in the long-term changes in perception of job characteristics at the level of the companies. Several studies have shown associations between the organizational context and level of stability on the one hand and the perception of psychosocial job characteristics and job insecurity on the other (Härenstam *et al*, 2000; Westerlund *et al*, 2004). A notable gender difference was found in relation to the perception of job insecurity, with an average increase of 16% for men, while the situation for women was better at almost 2%. Although the difference was independent of educational level or occupational class, it could be that even within the same occupational class, men are more likely to be employed in rather unstable jobs with higher risk of discharge, while women prefer rather low-profile jobs with more stability and security. It has been suggested that the experience of unemployment and job insecurity is more problematic for men because they perceive work as their core role in society, while women are protected by their alternative role in taking care of the household and children (De Witte, 1999). This could also explain why men and women perceive their situation of job insecurity in different ways, even though they are facing the same changes in the labor market.

Limitations of the study

The main limitation of this study is that the results are not based on a random sample of the working population, as a result of which our findings cannot be generalized to all workers in Belgium. However, the population contains substantial variation in companies and occupational groups. The selection of nine companies at T2 was mainly based on practical grounds. Since, however, no considerable differences in sociodemographic factors or perception of job characteristics at baseline were observed compared with the non-selected companies, it is fair to assume that this selection does not significantly bias our results. Within the nine companies involved, all prior participants of Belstress I were invited to participate in the second phase of the study. More than half of the original population in these companies was no longer eligible due to retirement, resignation, dismissal, chronic disease or decease. Some

companies had undergone major reorganizations with subsequent discharges as a result of which the population of possible participants had been reduced considerably. Obviously this results in a survivor-bias within our population. When comparing the study sample with the 'drop-out' population, a healthy-worker effect indeed becomes visible. At baseline, the 'drop-out' population perceived significantly less job control, more job insecurity and more impact of WMC. Consequently, it is likely that the increases we observed in feelings of job insecurity and the impact of WMC were underestimated. Of the eligible workers, 67.2% actually participated in the study. The non-respondents were on average older and lower educated, which might have influenced our results.

In exploring the dynamics in the perception of the JCQ scales, 331 participants who changed job category between T1 and T2 were excluded from the analyses. This was done in order to rule out changes in perception that were due to objective changes in job title. Evidently this does not mean that we have excluded all possible objective job changes. First, only those whose job title changed according to the first digit of the International Standard Classification of Occupations were excluded. Also, no information on changes of job contents within the same job title was available. In particular, workers often gain skills or get promoted with time and age. Therefore, it cannot be excluded that the modest average increase in perceived job control within the study sample is related to this natural process.

Implications and future research

The Belstress II study was set up mainly to explore long-term dynamics in job stress perception in relation to health outcomes. Based on our results, perceptions of job characteristics appeared to be relatively stable over time, which is of importance for work-related health research. A few studies have shown that health effects are more harmful when exposure to job stress is cumulative (Schnall *et al*, 1998; de Lange *et al*, 2002).

Our results regarding the increase in job insecurity and impact of WMC have serious implications for public health. Several studies have pointed out that job insecurity and precarious employment have adverse effects on psychological well-being and health status (Ferrie *et al*, 1998; Ferrie, 1999; De Witte, 1999; Benavides *et al*, 2000; Ferrie *et al*, 2002; Pelfrene *et al*, 2003c; Lee *et al*, 2004). Additionally it is suggested that high levels of job insecurity have negative implications for the organizational effectiveness

due to a decline in employees' commitment and job performance (Hartley, 1999). Based on these findings, we recommend that job stress studies should not only take job characteristics like demands and control into account, but additionally focus on job insecurity and impact of WMC. Within the context of the changing labor market, these dimensions are becoming increasingly important. Moreover, it is suggested that the adverse effects of job insecurity are largely independent of other psychosocial job characteristics (Ferrie *et al*, 2001; Souza *et al*, 2003).

CHAPTER 2

High Job Strain and Ambulatory Blood Pressure in Middle-Aged Men and Women from the Belgian Job Stress Study

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***Journal of Occupational and Environmental Medicine* 2007; Vol. 49: 360-367**

Abstract

Objective. The aim was to assess whether job strain is associated with 24-hour ambulatory blood pressure measurements within a subsample of the Belgian Job Stress Project (BELSTRESS) population. *Methods*. A group of 89 middle-aged male and female workers perceiving high job strain and an equally large group of workers perceiving no high job strain wore an ambulatory blood pressure monitor for 24 hours on a regular working day. *Results*. Mean ambulatory blood pressure at work, at home, and while asleep was significantly higher in workers with job strain as compared with others. The associations between job strain and ambulatory blood pressure were independent from the covariates. *Conclusions*. Within this study, high job strain was an important independent risk factor for higher ambulatory blood pressure at work, at home, and during sleep in a group of men and women.

Introduction

There is convincing evidence in the literature that psychosocial factors play an important role in the incidence and progression of coronary heart disease (Hemingway & Marmot, 1999; Steptoe, 1999; Strike & Steptoe, 2004). A considerable part of this research concentrates on the link between occupational stressors and cardiovascular disease. The introduction of the Job Demand - Control model by Karasek in the seventies gave impetus to more epidemiological studies in this field (Karasek, 1979; Johnson & Hall, 1988; Karasek *et al*, 1998). According to this model, the most adverse health effects are expected when workers are exposed to high psychological demands in combination with low decision latitude or job control; this combination is labeled as 'high job strain'. Numerous studies have used Karasek's job strain model to investigate associations between job strain and cardiovascular disease. Several reviews came to the conclusion that the evidence of an association is strong and consistent in men, while results in women are sparse and less consistent (Schnall *et al*, 1994; Belkic *et al*, 2000; Belkic *et al*, 2004). According to these reviews, the strongest empirical evidence concerning potential mediating mechanisms in the association between job strain and cardiovascular disease is found for elevated blood pressure (BP), particularly when assessed through ambulatory measurements. It is known that BP levels are notably related to lifestyle factors such as salt and alcohol consumption, excess body fat and physical inactivity; and although the role of psychosocial stress is less clear, job strain is considered a likely risk factor for hypertension (Beilin *et al*, 1999).

When evaluating studies linking occupational stress to casual BP measurements, results are generally not very consistent. Positive associations between job strain and hypertension or BP levels have been found in some (Schnall *et al*, 1990; Su *et al*, 2001; Cesana *et al*, 2003) but not in all studies (Chapman *et al*, 1990; Albright *et al*, 1992; Curtis *et al*, 1997; Tsutsumi *et al*, 2001b; Alfredsson *et al*, 2002). The evidence is much more consistent when BP is measured using discontinuous ambulatory recordings during several hours. A number of studies have shown higher levels of ambulatory BP in workers perceiving high job strain according to the Demand - Control model as compared with others (Light *et al*, 1992; Schnall *et al*, 1992; Van Egeren, 1992; Cesana *et al*, 1996; Schnall *et al*, 1998; Fauvel *et al*, 2001; Tobe *et al*, 2005). Significant associations were also found when job strain was identified through objective classification of occupations (Theorell *et al*, 1991; Rau, 2004). On the whole,

the relationship between occupational stress and higher BP in women is rather ambiguous compared with that in men (Pickering *et al*, 1996; Riese *et al*, 2004).
Within the BELSTRESS study, comprising 21,419 middle-aged men and women, no associations were found between high job strain and casual measures of BP (Pelfrene *et al*, 2002a). Higher job demands were related to higher BP levels, but only in men. The aim of this study was to assess whether the perception of job strain is associated with 24-hour ambulatory BP measurements within a subsample of the BELSTRESS population.

Materials and Methods

Study population and data collection

The association between job strain and ambulatory BP was assessed using cross-sectional data from BELSTRESS, an epidemiological cohort study about job stress, cardiovascular disease, sickness absence, and other health issues (Moreau *et al*, 2004; De Bacquer *et al*, 2005). The second phase of this study was conducted in 2002 and 2003. A total number of 2,821 men and women between 40 and 64 years old, working in 9 companies or public administrations across Belgium, who participated in the first survey, were involved. All participants volunteered to complete a self-administered questionnaire and go through a bioclinical examination. A participation rate of 68.5% was reached. The ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels approved the BELSTRESS study.
Perceived stress at work was measured by means of the Job Content Questionnaire (JCQ), based on Karasek's job strain model (Karasek, 1985; Karasek *et al*, 1998). Psychological job demands were measured by nine items. Job control or decision latitude is composed of two subscales: 'skill discretion' (six items) and 'decision authority' (three items). Based on the gender-specific median split of both JCQ scales, participants perceiving high job strain (high demands combined with low control) were differentiated from others (low job strain, actives and passives). Five JCQ items composing the scale of physical demands of the job were also included in the questionnaire.
The questionnaire contained additional information on educational level (low, medium, or high). Low education was defined as primary school level only, medium education as

secondary school level, and high education as high school or university. Occupations were defined according to the International Standard Classification of Occupations and grouped into executives, white-collars, and blue-collar (ILO, 1990). Participants were asked about their regular alcohol consumption and smoking status (current smokers vs others). Stress outside work was measured by a scale based on eight items regarding problems in the private life (Klitzman *et al*, 1990). Feelings of depression were rated based on 11 items from the Center for Epidemiological Studies-Depression scale (Radloff, 1977). Sleep problems were assessed by two items.

Participants were medically examined by trained members of the research team, using standardized methods. The medical visit took place in the medical office at the workplace. Body mass index was calculated as body weight (kg) divided by the square of the height (m). Casual systolic and diastolic BP was calculated as the average of two subsequent readings in a sitting position.

Subsample and 24-hour monitoring procedure

From the study group of 2,821 participants, a sample was selected for the substudy with ambulatory BP measurements. People taking medication for elevated BP or for hypotension were excluded from the substudy. Participants with a previous hospitalization for coronary heart disease were also considered ineligible. There were no other exclusion criteria. Eligible persons were invited to participate by means of a personal letter, in which the content of the substudy was described. A group of 89 workers perceiving high job strain was randomly selected from the participants within 4 companies. An equally large group of workers perceiving no high job strain were matched for gender, occupation, and company as closely as possible. This population of 178 participants comprises 65.6% of the invited subjects.

At the start of a regular working day, a trained member from the research team initiated the 24-hour monitoring procedure at the workplace. For 24 hours, participants wore a SpaceLabs Medical ambulatory BP monitor (Model 90121, SpaceLabs Medical, Inc., Redmond, WA). The monitor was programmed to measure the arterial BP every half hour during the day (from 6 am until 10 pm) and every hour at night (from 10 pm until 6 am). During the day, every measurement was preceded by a warning tone. Participants were asked to keep their arm motionless and in vertical position beside the body every time they heard the tone. In case a measurement failed due to excessive motion of the body, a new reading automatically followed a few minutes later. Before the automatic

measurements started, two subsequent test readings were manually initiated to make participants familiar with the process. In order to measure the physical activity during the 24-hour monitoring, a Computer Science and Applications activity monitor (Model 7164, Computer Science and Applications, Inc., Shalimar, FL) was attached to the waist. This single-channel Actigraph continuously records accelerations of the body and has been proven a valid tool in assessing physical activity (Melanson & Freedson, 1995).

Participants were asked to perform their regular activities at work and at home during the monitoring period, and not to detach the devices until the next day. They were also asked to register their 24-hour schedule (time spent at work, at home, and sleeping) in a diary.

Statistical analyses

The editing criteria of the SpaceLabs monitor were set to reject readings when systolic BP was >240 mmHg or <70 mmHg and when diastolic BP was >150 mmHg or <40 mmHg. Based on the information from the diaries, the average ambulatory BP of every participant was calculated for the periods at work, at home, and during sleep. The average sleep BP could not be calculated for three participants because there were no valid readings at night. Apart from this, there were never less than two readings and in at least 90% of the participants five readings or more for the averages at work, at home, and while asleep. The average number of readings was 16 ± 3 for the work period, 14 ± 3 for the home readings, and 7 ± 2 for the readings during sleep.

The activity monitor was programmed to register an activity count on every minute during the 24-hour monitoring. In all participants, the average physical activity level preceding every ambulatory BP reading was assessed. For each reading, we calculated the average of the count during the reading and the counts on the five minutes preceding the reading. On group level, the mean of the average activity levels was assessed for the work, home, and sleep periods. Natural logarithm (ln) transformations were performed because of the skewed distributions.

As for the main analyses, χ^2 and *t* tests were performed to compare workers with and without job strain in terms of descriptive characteristics and risk factors for high BP. Crude and adjusted means of ambulatory BP were evaluated in both groups using analyses of variance (ANOVAs). We assessed all possible interactions between job strain and other risk factors in relation to ambulatory BP. Adjusted associations were

evaluated between ambulatory BP and quartile groups of job demands and job control, and quadrant groups of job strain. All analyses were conducted using SPSS 12.0 software (SPSS, Inc., Chicago, IL).

Results

Table 2.1 shows the descriptive characteristics and risk factors for elevated BP in those with high job strain (89 workers) and others (89 workers). The high strain group contained significantly more current smokers, more workers with high physical job demands, more people with high stress outside work, more with high feelings of depression, and more with severe sleep problems.

Table 2.1 Descriptive characteristics of the high job strain group (n = 89) and others (n = 89)

Characteristics	High job strain	No high job strain	*P* Value
Gender, % (n)			0.44
Men	64.0 (57)	58.4 (52)	
Women	36.0 (32)	41.6 (37)	
Age (yr), mean (SD)	51.9 (4.3)	50.9 (5.0)	0.18
Educational level, % (n)			0.26
Low	38.6 (34)	39.1 (34)	
Medium	40.9 (36)	31.0 (27)	
High	20.5 (18)	29.9 (26)	
Occupation, % (n)			0.68
Executives	8.0 (7)	8.0 (7)	
White-collar	63.6 (56)	69.3 (61)	
Blue-collar	28.4 (25)	22.7 (20)	
Sector of employment, % (n)			0.93
Secondary	20.2 (18)	18.0 (16)	
Tertiary	12.4 (11)	12.4 (11)	
Public	67.4 (60)	69.7 (62)	
Body mass index (kg/m²), mean (SD)	26.5 (3.8)	25.8 (3.2)	0.22
Current smoker, % (n)	31.5 (28)	15.7 (14)	0.01
Alcohol consumption (units/wk), mean (SD)	12.0 (9.7)	12.1 (11.9)	0.92
High physical demands of the job, % (n)*	24.7 (22)	13.6 (12)	0.06
High levels of stress outside work, % (n)*	34.1 (30)	18.0 (16)	0.02
High levels of feelings of depression, % (n)*	36.0 (32)	14.8 (13)	<0.001
Sleep problems, % (n)*	33.7 (30)	20.2 (18)	0.04
Activity count prior to BP measurements (ln), mean (SD)	5.36 (0.54)	5.25 (0.54)	0.18

* upper quartile of the scale; SD indicates standard deviation; BP, blood pressure

In both groups, the highest mean ambulatory BP was observed at work, followed by ambulatory BP at home and during sleep (Table 2.2). Ambulatory BP at work was

significantly higher in workers with job strain as compared with others, with differences of 6.5 mmHg in systolic BP and 3.1 mmHg in diastolic BP. The significant increase in ambulatory BP in the high strain group was maintained during the periods at home and while asleep; the difference for the diastolic BP at home, though, was only borderline significant. In multivariate ANOVAs, adjusted means were controlled for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, and mean level of physical activity prior to BP measurements. The differences in ambulatory BP between workers with and without job strain remained highly significant after adjusting for covariates. Since educational level, occupation, company, and alcohol consumption did not discriminate between the job strain groups, these variables were not included in the model. No adjustments were made for depressive feelings and sleep problems, because additional analyses indicated that these factors did not play an intermediate role in the association between job strain and BP.

Casual BP at the worksite (results not shown here) was also higher in the high strain group, with differences of 4.3 and 0.7 mmHg in adjusted mean systolic and diastolic BP as compared with others; however, these differences did not reach statistical significance. Moreover, the association between job strain and ambulatory BP at work was independent from casual worksite BP.

In multivariate analyses, several other risk factors in addition to job strain proved to be important determinants of ambulatory BP. Concerning systolic BP, positive associations were assessed with body mass index and physical demands of the job, whereas diastolic BP was positively related to alcohol consumption and male gender. After adjustments for job strain and covariates, a borderline significant relationship between stress outside work and diastolic home BP was found (P=0.08), with a difference of 2.5 mmHg between people with high stress outside work and others.

None of the terms of interaction between job strain and other risk factors in relationship to ambulatory BP were significant. It should be noted, though, that the association between job strain and diastolic BP was larger in older participants, with a significant elevation of 5.0 mmHg in diastolic BP at work in subjects aged 50 years or older opposed to a not significant elevation of 0.7 mmHg in others. Also, job strain was not related to ambulatory diastolic BP in workers with high physical job demands, whereas a significant elevation of 3.5 mmHg in BP at work was found in others.

No significant interactions between job demands and decision latitude in relationship to ambulatory BP were found. Consequently, the association between high job strain and higher BP was mainly due to the additive rather than the interactive effects of both

components of the Demand – Control model. The adjusted mean ambulatory BP at work for the quartiles of job demands and job control is shown in Table 2.3. Strong and significant associations were primarily found between low job control and higher BP at work, with differences of 11.7 mmHg in systolic BP and 6.7 mmHg in diastolic BP between the first and the last quartile group. In addition, the differences between extreme quartile groups of job control - but not job demands - were significant regarding adjusted mean systolic BP at home and systolic and diastolic BP during sleep (results not shown here). Moreover, the associations between decision latitude and ambulatory BP remained significant after additional adjustment for job demands.

Table 2.2 Crude and adjusted associations between job strain and ambulatory blood pressure (mmHg)

	Crude means (SD)			Adjusted means*		
	High job strain	No high job strain	*P* Value	High job strain	No high job strain	*P* Value
Ambulatory systolic BP						
At work	134.3 (12.2)	127.8 (10.5)	<0.001	135.2	129.3	<0.001
At home	131.7 (11.5)	127.2 (9.4)	0.01	133.1	129.3	0.02
During sleep	115.9 (11.9)	110.4 (10.7)	<0.001	118.0	113.5	0.02
Ambulatory diastolic BP						
At work	86.6 (9.3)	83.5 (8.1)	0.02	86.4	83.4	0.03
At home	83.8 (8.3)	81.6 (7.4)	0.07	84.0	81.9	0.10
During sleep	70.7 (8.7)	66.6 (7.7)	<0.001	71.3	67.4	0.01

* Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, and mean level of physical activity prior to blood pressure measurements; SD indicates standard deviation; BP, blood pressure

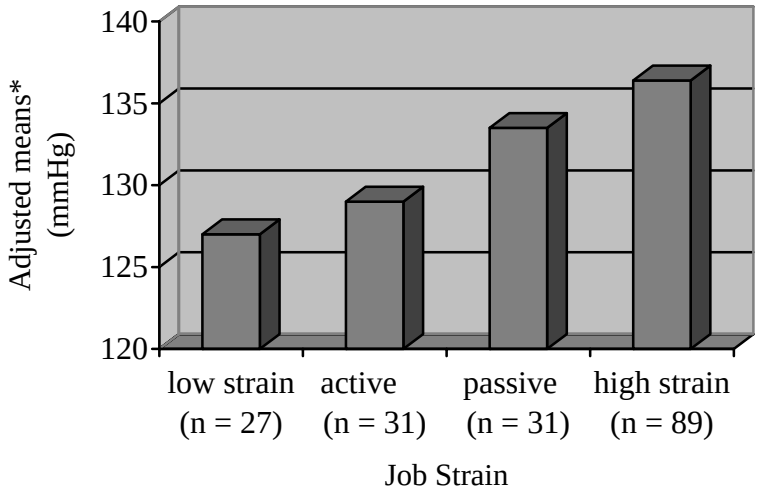
Table 2.3 Adjusted associations between quartiles of job demands, job control, and ambulatory blood pressure at work (mmHg)

	Adjusted means*			
	Systolic BP at work	*P* Value	Diastolic BP at work	*P* Value
Job Demands		0.04		0.18
Quartile 1	129.7		83.8	
Quartile 2	130.7		84.5	
Quartile 3	135.1		86.1	
Quartile 4	136.2		88.0	
Job Control		<0.001		0.02
Quartile 1	139.2		88.9	
Quartile 2	132.3		85.4	
Quartile 3	132.9		85.9	
Quartile 4	127.5		82.2	

* Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, mean level of physical activity prior to blood pressure measurements, and occupation; BP indicates blood pressure

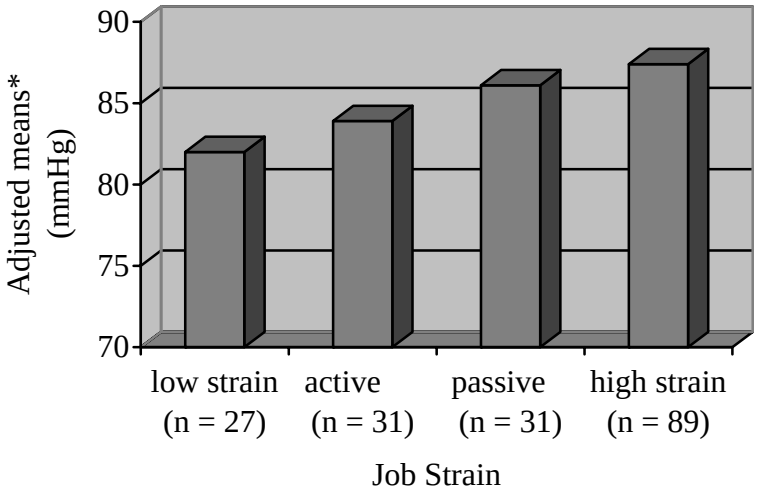
The predominant role of low decision latitude in the association between high job strain and ambulatory BP was confirmed when mean systolic and diastolic BP was compared between the job strain quadrant groups (Figures 2.1 and 2.2). Highest mean systolic and diastolic BP at work was found in the groups with low job control: the high strain group (136.4/87.4 mmHg) followed by the passive group (133.5/86.1 mmHg). These groups were closely related to each other in terms of ambulatory BP at work and diverged substantially from the active group (129.0/83.9 mmHg) and the low strain group (127.0/82.0 mmHg).

Figure 2.1 Adjusted association between quadrant groups of job strain and mean systolic blood pressure at work (mmHg)



* Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, mean level of physical activity prior to blood pressure measurements, and occupation

Figure 2.2 Adjusted association between quadrant groups of job strain and mean diastolic blood pressure at work (mmHg)



* Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, mean level of physical activity prior to blood pressure measurements, and occupation

Discussion

The aim of this study was to explore perceived job strain according to the Demand - Control model in relationship to ambulatory BP within a sample of middle-aged men and women. Ambulatory BP measurements within 24-hours were evaluated in a group of 89 workers with high job strain and in an equally large number of workers perceiving no high strain. We detected strong and consistent associations between high job strain and ambulatory BP. The impact was not limited to an increased BP at work; mean ambulatory BP at home and during sleep were also higher in workers with high strain. It is important to note that the associations in this study were independent of other risk factors of high BP (ie, gender, age, body mass index, smoking, physical demands of the job, stress outside work, and physical activity prior to BP measurements). With the use of the activity monitor, proper adjustment for physical activity could be attained. Physical activity is an essential determinant of ambulatory BP, and several studies have shown strong correlations between ambulatory BP and average physical activity prior to the measurement (Gretler *et al*, 1993; Kario *et al*, 1999; Leary *et al*, 2000). Consequently, it is highly recommended that ambulatory BP data be interpreted in the light of activity data averaged over the minutes preceding BP assessments. A study with ambulatory BP monitoring and actigraphy in 160 subjects found that physical activity during the BP measurement and the preceding 5 minutes was the best

predictor of the within-person fluctuations in ambulatory BP, an approach which we followed in processing the data (Kario *et al*, 1999).

The highest mean systolic and diastolic BP measurements were observed at the workplace, followed by mean systolic and diastolic BP at home and during sleep, which is in line with expectations (Pickering *et al*, 1982; Pieper *et al*, 1993). The effect sizes in our study - differences of 6.5 and 3.1 mmHg in systolic and diastolic BP at work between the high job strain group and others - were very similar to those found in the Work Site Blood Pressure Study, a study with 24-hour ambulatory BP measurements in 264 men from eight New York work sites (Schnall *et al*, 1992).

A similar impact of job strain on ambulatory BP was found in both men and women. Thus, the results of this study suggest that perceived job stress is a risk factor for higher BP not only in men but also in women, contrary to some other studies that highlight the inconsistent findings in women (Pickering *et al*, 1996; Riese *et al*, 2004).

In a number of studies, job stress measures were related to systolic ambulatory BP whereas no association was found with diastolic BP (Cesana *et al*, 1996; Melamed *et al*, 1998; Vrijkotte *et al*, 2000; Gallo *et al*, 2004). High job strain within our population resulted in significant elevations in both systolic and diastolic BP, although the associations with diastolic BP were smaller.

Our results support the idea that ambulatory measurements of BP are more appropriate than casual assessments to explore associations with job stress, which confirms other studies (Fauvel *et al*, 2001; Kamarck *et al*, 2002). Only ambulatory BP, but not casual worksite BP, was consistently and independently higher in workers with high job strain. It is generally accepted that ambulatory monitoring results in a more accurate characterization of an individual's BP because it is based on multiple assessments during normal life activities and also because the "white-coat effect" is avoided (Georgiades, 1997).

Contrary to job strain, the perception of stress outside work as measured in this study did not seem to be an essential determinant of ambulatory BP. Regarding diastolic BP at home, though, both job strain and stress outside work generated comparable, borderline significant effects. Job strain was strongly related to feelings of depression, as was found in many other studies (Van Der Doef & Maes, 1999). However, we were unable to discover any relationship between feelings of depression and ambulatory BP. Thus, this study underlines the importance of the psychosocial work environment in contrast to psychological variables in relation to BP, which is in line with findings from the Work Site Blood Pressure Study (Friedman *et al*, 2001).

Although the interaction term was not statistically significant, the impact of job strain on diastolic BP was considerably more pronounced in workers aged 50 years or older. The Work Site Blood Pressure Study also found greater effects of job strain on BP with increasing age (Schnall *et al*, 1990; Schnall *et al*, 1992). In workers with high physical demands of the job, job strain did not result in higher diastolic BP. The same finding was reported by Theorell *et al* (1991) in a study including 161 men with borderline hypertension. Several studies have reported modifying effects of socioeconomic status in the relationship between job stress and BP. Within the Work Site Blood Pressure Study, larger associations between job strain and ambulatory BP were found in men with lower socioeconomic status (Landsbergis *et al*, 1999; Landsbergis *et al*, 2003b). Gallo *et al* (2004) only found an association between job strain and ambulatory BP in women in lower occupations. Two studies including white-collar women reported that high job strain was only related to ambulatory BP in women with a higher educational level (Laflamme *et al*, 1998; Brisson *et al*, 1999). No interaction between job strain and socioeconomic status in relationship to BP was found in our study. High job strain was associated with increased ambulatory BP in all occupational groups and educational levels.

A number of studies have emphasized the confirmation of Karasek's Demand - Control model regarding ambulatory BP, since only the combination or interaction of job demands and decision latitude resulted in higher BP, while no independent effects of the separate components were observed (Schnall *et al*, 1990; Theorell *et al*, 1991; Light *et al*, 1992; Schnall *et al*, 1992; Van Egeren, 1992; Melamed *et al*, 1998). The association between high job strain and ambulatory BP in our study, however, was due to the additive effects of job demands and job control; no significant interactions were found. The negative association between ambulatory BP and decision latitude was especially consistent and independent of covariates. The predominant role of low job control in association with ambulatory BP in men and women was also discovered by Steptoe & Willemsen (2004).

The results of this study confirmed that high job strain is causally related to higher ambulatory BP. Nevertheless, possible alternative explanations should be considered. When exposure to job stress is assessed through self-reports, it is essential that awareness of having hypertension and treatment for the disease are accounted for, because these conditions are likely to cause information bias (Nyklicek *et al*, 1996). People with hypertension who are labeled as having high BP might give biased responses to questions regarding work stressors. None of the participants in this study

were medically treated for hypertension. A total of 20 subjects from the high job strain group reported that a physician once told them that they have elevated BP. However, additional adjustment for this condition of awareness of elevated BP only marginally changed the results regarding job strain and ambulatory BP.

Participants in the BELSTRESS study were not recruited from a representative sample of the active working population in Belgium, which may limit the external validity of the results. Nonetheless, the study cohort covers a broad range of companies and occupational groups. As for the selection of participants in the substudy, a considerable rate of response was reached as two of three invited workers were willing to participate. Moreover, in all probability there was no severe selection bias, since no differences concerning general characteristics and perception of job stress were found between the high job strain and the no high job strain group in the substudy and their equivalents in the total population.

The results presented here are based on a single assessment of perceived job strain. This increases the risk of misclassification due to inaccuracy in measurement, a result of which the associations found here are likely underestimations, or at least conservative estimates of the truly existing relationships between job stress and BP (Landsbergis *et al*, 2002). Longitudinal analyses concerning job strain and ambulatory BP were performed within the population of 195 men from the Work Site Blood Pressure Study (Schnall *et al*, 1998). Participants with cumulative exposure to job strain on two occasions three years apart had higher ambulatory BP on the second occasion than those exposed to job strain at only one assessment. Negative findings were reported in a longitudinal study including 292 men and women, in whom job strain at baseline was not related to ambulatory BP after a 5-year follow-up period (Fauvel *et al*, 2003). Further research with longitudinal study designs is needed in order to clarify the exact nature of the relationship between job strain and BP.

Conclusion

In conclusion, based on this study and other studies, there is convincing evidence for consistent associations between self-perceived job strain and ambulatory BP. Within this study, high job strain was an important independent risk factor for higher BP at work, at home, and during sleep in a group of men and women. Our results suggest that low decision latitude plays the predominant role in the association. Although the effect sizes found in our study may not be clinically relevant on the individual level, they

are very significant in a public health approach. It has been estimated that a reduction in systolic BP of about 10 mmHg (or 5 mmHg diastolic BP) results in about a 20% to 25% lower risk of coronary heart disease, and that half of coronary heart disease worldwide is attributable to nonoptimal BP (Lawes *et al*, 2005).

CHAPTER 3

Associations Between Dimensions of Job Stress and Biomarkers of Inflammation and Infection

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Journal of Occupational and Environmental Medicine **2005; Vol. 47: 878–883**

Abstract

Objective. The objective of this study was to examine associations between dimensions of job stress and indicators of chronic inflammation and infection. *Methods*. Within a subsample from the BELSTRESS study of 892 male subjects free of cardiovascular disease, dimensions of job stress from the Job Demand – Control - Support model were related to biomarkers of inflammation (plasma fibrinogen concentrations, high-sensitivity C-reactive protein, and serum amyloid A) and infection (titers against Chlamydia pneumoniae, cytomegalovirus, and Helicobacter pylori). *Results*. A negative association was found between job control and plasma fibrinogen concentration, independent from age, education, occupation, body mass index, smoking, alcohol consumption, and use of lipid-lowering and antihypertensive medication. Higher social support at work was independently related to an increased risk of positive titers against cytomegalovirus. *Conclusions*. Results confirmed previous findings regarding elevated plasma fibrinogen and low job control.

Introduction

For many years, psychosocial factors have been suggested as possible intervening elements in the causation of cardiovascular disease (CVD), with occupational stress as a major issue of attention (Schnall *et al*, 1994; Bosma *et al*, 1997; Hemingway & Marmot, 1999; Belkic *et al*, 2000; Schnall *et al*, 2000; Karasek & Theorell, 2000; Belkic *et al*, 2004). One of the most influential and widely used models in this field is the Job Demand - Control - Support (JDCS) model, introduced by Karasek in the 1970s (Karasek, 1979; Karasek *et al*, 1998). Because classic risk factors such as blood pressure and blood lipids cannot fully account for the association between job stress and CVD, alternative pathways have been explored. Recently, chronic inflammation and infection have been suggested as possible mediating mechanisms. There is growing evidence for the role of inflammatory processes in the development and progression of CVD (Ernst, 1991; Danesh *et al*, 1998; Koenig *et al*, 1999; Harris *et al*, 1999; Danesh *et al*, 2000a; Delanghe *et al*, 2002; Retterstol *et al*, 2002; De Backer *et al*, 2002). Additionally, it is suggested that chronic infections contribute to inflammatory activity and hence to the development of CVD, although results are less consistent (Mendall, 1998; Pasceri *et al*, 1998; Danesh *et al*, 1999; Gupta, 1999; Yudkin *et al*, 1999; Ridker *et al*, 2000; Danesh *et al*, 2000b; Delanghe *et al*, 2002; De Backer *et al*, 2002).

Given the growing support for the predictive value of inflammatory and, to a lesser extent, infectious parameters regarding CVD, these mechanisms are possible intermediate variables linking psychosocial job stress to elevated risk of CVD. Hence, it is hypothesized that psychosocial stress is associated with markers of inflammation and infection. Excessive job stress could make a subject more susceptible to infection and/or by an altered immune system induce chronic inflammation. Plasma fibrinogen levels have been related to job strain in several studies, but results are not consistent (Theorell, 2002). The aim of this study is to examine cross-sectionally whether dimensions of job stress from the JDCS model relate to biomarkers of chronic inflammation—fibrinogen, C-reactive protein (CRP), and serum amyloid A (SAA)—and infection—Chlamydia pneumoniae (CP), Helicobacter pylori (HP), and cytomegalovirus (CMV)—in a sample of 892 males free of clinical coronary heart disease.

Materials and Methods

Subjects

The assumed link between occupational stress and markers of inflammation and infection has been tested with data from the BELSTRESS project, a large epidemiologic cohort study about job stress, cardiovascular, and other health issues and sickness absence (Coetsier *et al*, 1996). Within 25 large companies or public administrations across Belgium, all workers aged 35 to 59 years were personally invited to participate in the study. Between 1994 and 1998, a total of 21,419 respondents (16,329 men and 5,090 women) completed a questionnaire and underwent a medical examination. A participation rate of 48% was reached. Within the BELSTRESS project, a case–control study was set up in which 446 cases with evidence of coronary heart disease were identified (De Backer *et al*, 2002). Twice this number of subjects were matched on working environment, age, and educational level. Results here are based on this sample of 892 male subjects free of clinical coronary heart disease. These workers were recruited from 13 private companies (55% of the sample), 4 public administrations (28%), 6 banks and insurance companies (16%), and 2 hospitals (1%). The sample contains 116 executives (13%), 402 white collar workers (47%), and 343 blue collar workers (40%).

Questionnaire

Dimensions of job stress were assessed using a self-administered questionnaire—the Job Content Questionnaire (JCQ)—that measures 3 dimensions of the job. Psychological job demands and job control each contain 9 items; social support at work was measured by 8 items (co-worker and supervisor support, 4 items each) (Karasek, 1985; Karasek *et al*, 1998). In case of 1 missing value per (sub)scale concerning the dimensions of demands, control, and support, the mean value that is calculated over the set of remaining valid (sub)scale items for that particular respondent was imputed, picking up 5% more valid cases at most. Reliability and validity of these scales within the BELSTRESS project have been demonstrated (Pelfrene *et al*, 2001). The population was divided into 3 groups regarding the scales of job demands, job control, and social support based on the values of the tertiles. The construct of high job strain refers to the combination of high levels of job demands (values above the median) with

low levels of job control (values below the median). This category is contrasted to all other possible combinations of levels of job demands and job control. The 'iso(lated)-strain' group is composed of participants with high job strain combined with low levels of social support at work (values below the median). The questionnaire also included information on age, educational level, smoking behavior, alcohol consumption, and use of lipid-lowering and antihypertensive medication.

Biomedical examination and analysis of blood samples

Participants were medically examined by trained observers using standardized methods. Body mass index (BMI) was calculated as body weight (in kilograms) divided by the square of the height (in meters). Blood samples were drawn from sitting, nonfasting individuals at the time of their clinical examination. Blood was allowed to clot, centrifuged, and the supernatant serum was kept frozen at -70°C until analysis. Blood was simultaneously collected in tubes containing trisodium citrate for the determination of plasma fibrinogen. Measurements were made by trained technicians. Assessments were made of plasma fibrinogen, SAA, and high-sensitivity CRP concentrations, and of titers against CP, CMV, and HP. Detailed information about blood analyses has been published elsewhere (De Backer *et al*, 2002).

Statistical analyses

Given the skewed nature of the distributions of the inflammatory variables plasma fibrinogen, CRP, and SAA, natural logarithm (ln) transformations were performed, which resulted in normal distributions. The relation between dimensions of job stress from the JDCS model and these inflammatory biomarkers was analyzed by means of one-way analysis of variance on the differences in geometric means. A post hoc test (Tukey-HSD) was performed to make pairwise comparisons of the factor level means.
The infectious parameters CP, CMV, and HP were treated as categorical variables, dividing subjects in having either negative or positive titers against these biomarkers. Logistic regression analyses were conducted in which the odds ratios refer to the risks of having positive titers against the infectious biomarkers. All statistical analyses were performed using SPSS software.

Results

Sample characteristics for basic variables and job stress dimensions are presented in Table 3.1. The median for plasma fibrinogen concentration in the population was 314.4 mg/dL (mean value 320.3 mg/dL and standard deviation [SD] 68.2), for CRP concentration 0.94 mg/L (mean value 2.06 mg/L and SD 4.7), and for SAA concentration 2.10 mg/L (mean value 5.04 mg/L and SD 18.7). As for the infectious parameters, dichotomous categorical variables were created. With respect to CP, the population was divided into 23% negatives and 77% positives, with the cut point set at 0.70 U/mL. The cut point for CMV was set at 70 U/mL, which results in 53% negatives and 47% positives. There were 64% negatives and 37% positives on the HP marker; a subject was considered seropositive if either IgG or IgA was above 10 U/mL.

Table 3.2 shows associations between inflammatory biomarkers and JDCS variables. Analyses of variance were performed on the ln-transformed plasma fibrinogen, CRP, and SAA concentrations. A significant negative association was found between job control and plasma fibrinogen concentration, independent from age, educational level (in three categories: low, medium, and high), occupational group (in three categories: executives, white-collar workers, and blue-collar workers), BMI, smoking status (smoker vs. nonsmoker), alcohol consumption (g/d), use of lipid-lowering medication (yes vs. no), and use of antihypertensive medication (yes vs. no). The difference in mean plasma fibrinogen concentration between the group perceiving high and those perceiving low or medium job control reached borderline significance (P=0.06). Subjects with high social support at work tended to have a higher mean plasma fibrinogen concentration, but this association was not significant when adjusting for covariates. None of the job stress dimensions correlated with mean concentrations of CRP and SAA.

Table 3.1 Sample characteristics for basic variables and dimensions of job stress (n = 892)

Characteristics	Mean (SD); Median; Percent (n) or Tertiles
Age (yr): mean (SD)	49.7 (5.4)
Body mass index (kg/m²): mean (SD)	26.9 (3.6)
Alcohol (g/day): median	19.9
Current smoking: % (n)	35% (311/892)
Former smoking: % (n)	37% (334/892)
Use of lipid-lowering medication: % (n)	5% (48/892)
Use of antihypertensive medication: % (n)	9% (79/892)
Low education: % (n)	53% (473/892)
High education: % (n)	20% (179/892)
High job strain: % (n)	18% (164/892)
Iso-strain: % (n)	12% (107/892)
Job demands	
Mean (SD)	23.3 (4.2)
First tertile	21
Second tertile	25
Job control	
Mean (SD)	69.0 (12.8)
First tertile	66
Second tertile	74
Social support	
Mean (SD)	22.6 (3.8)
First tertile	21
Second tertile	24

SD indicates standard deviation

Table 3.2 Association between ln-transformed fibrinogen (mg/dl), C-reactive protein (mg/l), and Serum amyloid A (mg/l) values and dimensions of job stress in 892 males using Analysis of Variance

	Fibrinogen			C-reactive protein			Serum amyloid A		
	Geometric mean	*P*	*P**	Geometric mean	*P*	*P**	Geometric mean	*P*	*P**
Job strain									
No	313.8	0.60	0.30	0.94	0.68	0.67	2.29	0.98	0.98
Yes	316.5			0.98			2.29		
Iso-strain									
No	314.1	0.94	0.52	0.96	0.62	0.91	2.30	0.98	0.66
Yes	314.5			0.90			2.29		
Job demands									
T1	314.1	0.90	0.63	1.00	0.53	0.83	2.16	0.10	0.13
T2	315.6			0.96			2.56		
T3	313.2			0.90			2.25		
Job control									
T1	318.0	0.04	0.03	0.96	0.62	0.18	2.25	0.91	0.80
T2	318.3			1.00			2.29		
T3	307.2			0.91			2.32		
Social support									
T1	309.7	0.05	0.18	0.85	0.13	0.19	2.14	0.19	0.19
T2	312.7			0.99			2.35		
T3	323.4†			1.04			2.51		

T1, T2, T3 = tertiles of job stress scales; *Adjusted for age, educational level, occupational group, body mass index, smoking status, alcohol consumption, use of lipid-lowering medication and use of antihypertensive medication;
†p<0.05 - results Tukey-HSD post hoc test: significance of difference from first category

In logistic regressions, the risks were calculated of having positive titers against the infectious biomarkers CP, CMV, and HP (Table 3.3). Dimensions of job stress were in no way associated to the risk of scoring positive on CP and HP in the study population. A positive independent association was found between social support and CMV; participants with low or medium levels of social support at work had approximately 40% less risk of having positive titers.

Table 3.3 Association between dimensions of job stress (risks) and positive titers against Chlamydia pneumoniae, Cytomegalovirus, and Helicobacter pylori in 892 males using logistic regressions

		Unadjusted		Adjusted*	
		OR	95% CI	OR	95% CI
Chlamydia pneumoniae					
Job strain†	yes	1.15	0.74-1.80	1.24	0.76-2.01
Iso-strain†	yes	1.21	0.71-2.06	1.27	0.71-2.28
Job demands‡	T2	0.75	0.50-1.14	0.83	0.53-1.30
	T3	0.94	0.63-1.39	1.10	0.70-1.72
Job control	T1	1.06	0.71-1.56	1.08	0.68-1.69
	T2	1.13	0.76-1.69	1.18	0.76-1.83
Social support	T1	1.05	0.66-1.66	1.15	0.70-1.89
	T2	0.83	0.54-1.28	0.92	0.58-1.46
Cytomegalovirus					
Job strain†	yes	1.21	0.84-1.74	1.06	0.71-1.58
Iso-strain†	yes	1.34	0.87-2.06	1.15	0.71-1.84
Job demands‡	T2	0.96	0.67-1.37	1.23	0.83-1.82
	T3	0.99	0.71-1.37	1.25	0.85-1.82
Job control	T1	1.02	0.73-1.42	0.70	0.47-1.03
	T2	0.92	0.66-1.29	0.71	0.48-1.03
Social support	T1	0.62	0.42-0.90	0.62	0.40-0.94
	T2	0.61	0.42-0.88	0.57	0.38-0.86
Helicobacter pylori					
Job strain†	yes	0.91	0.63-1.32	0.78	0.52-1.18
Iso-strain†	yes	0.74	0.47-1.16	0.63	0.38-1.04
Job demands‡	T2	1.22	0.85-1.75	1.08	0.72-1.60
	T3	0.84	0.59-1.18	0.83	0.56-1.22
Job control	T1	1.15	0.81-1.62	0.93	0.62-1.38
	T2	1.08	0.76-1.54	0.96	0.65-1.42
Social support	T1	0.71	0.47-1.05	0.70	0.45-1.08
	T2	1.11	0.77-1.62	1.15	0.77-1.73

T1, T2, T3 = tertiles of job stress scales. Reference categories are third tertiles unless stated otherwise; *adjusted for age, educational level, occupational group, body mass index, smoking status, alcohol consumption, use of lipid-lowering medication, and use of antihypertensive medication; †reference category is "no"; ‡reference category is first tertile; OR indicates odds ratio; CI, confidence interval

Discussion

Associations between dimensions of job stress from the JDCS model and biomarkers of inflammation and infection were explored in a sample of 892 male subjects free of clinical coronary heart disease. A negative association was found between perception of job control and plasma fibrinogen concentration, independent from age, educational level, occupational group, BMI, smoking status, alcohol consumption, and use of lipid-

lowering and antihypertensive medication. Higher social support at work was independently related to an increased risk of positive titers against CMV.

Inflammation as a potential mediating mechanisms in the relation between stress and CVD has been extensively elaborated (Black & Garbutt, 2002; Strike & Steptoe, 2004). It has been suggested that perceived job stress may be related to elevated plasma fibrinogen, although results are not consistent (Davis *et al*, 1995; Ishizaki *et al*, 1996; Vrijkotte *et al*, 1999; Riese *et al*, 2000; von Kanel *et al*, 2001; Su, 2001; Theorell, 2002; Kittel *et al*, 2002). In general, the dimension of job control has been more consistently related to fibrinogen concentrations than job demands, which is in line with our findings (Tsutsumi *et al*, 1999; Su, 2001; Ishizaki *et al*, 2001; Alfredsson *et al*, 2002). Fewer studies have been conducted on possible associations between job stress and concentrations of CRP and SAA. Elevated concentrations of CRP have been found in people with higher job demands (Schnorpfeil *et al*, 2003). In the Whitehall study, however, no associations were found between plasma levels of CRP and job demands, job control, or social support (Hemingway *et al*, 2003). Based on our results, we were unable to show any relation between job stress dimensions and concentrations of CRP and SAA. These biomarkers are believed to be part of the acute phase response that is induced by stress, but stress may not be implicated in the direct induction of CRP and SAA (Black & Garbutt, 2002). Also, it recently has been suggested that the predictive value of CRP with regard to coronary heart disease may have been overestimated in earlier studies (Danesh *et al*, 2004). However, these findings do not imply that the idea of inflammation as a potential mediating mechanism between stress and CVD is not useful. More research is needed, for instance, on the proinflammatory cytokine IL-6. It is believed that psychosocial stress induces neuroendocrine stress responses by stimulation of the hypothalamic–pituitary–adrenal (HPA) axis and thus increases circulating levels of IL-6, which in turn is an important regulator of CRP (Zhou *et al*, 1993; Yudkin *et al*, 2000; Black & Garbutt, 2002).

It is hypothesized that the relation between stress and CVD may partly be mediated by an increased susceptibility to infectious disease, although the predictive value of infectious biomarkers regarding coronary heart disease is uncertain (Danesh *et al*, 2002). For a long time, it has been suggested that psychological distress may be associated with the onset of infectious diseases (Cohen & Williamson, 1991). Evidence of a negative association between stress and antibody response to vaccination has been shown (Burns *et al*, 2003). The scales of job demands and job control, as well as the high strain and iso-strain constructs, were not related to the risk of having positive

titers against CP, CMV, or HP in our sample. However, higher social support at work was independently related to an increased risk of positive titers against CMV. This is contrary tot expectations because social support has been negatively related to infection in a number of studies (Cohen & Williamson, 1991). Further research with larger numbers is needed to clear up this issue.

Participants in this study were not recruited from a representative sample of the active working population in Belgium, which may limit the external validity of the results. However, because the study cohort covers a broad range of companies and occupational groups, it can be expected to contain substantial variation in exposure to job stress. The participation rate of 48% within the BELSTRESS project is rather low, and hence a selection bias with respect to personal and job related characteristics cannot be ruled out. Unfortunately, no information was collected to elicit the effect of nonresponse. A random selection of eligible employees on the payroll list showed, however, that nonrespondents and respondents had comparable distributions of age and gender. Moreover, the cardiovascular risk profile of the 892 men involved in this study is in line with expectation for a male Belgian working population of that age range.

The main limitation of this cross-sectional study is that it does not allow conducting of prospective analyses. It might be that psychosocial job stress has a rather prolonged effect on biomarkers of inflammation and infection. Furthermore, dimensions of job stress were assessed at only one occasion, which results in increased risk of misclassifications as a result of inaccuracy in assessments (Landsbergis *et al*, 2002). Multiple assessments would also allow to identify situations of chronic or repeated perception of job stress. It has been argued that the progression of infection and inflammatory atherosclerosis is related to stressors that are recurrent or enduring (Black & Garbutt, 2002; Burns *et al*, 2003).

As a result of their intra-individual variability, the reproducibility of biological markers is undoubtedly restricted (de Maat *et al*, 1996; De Bacquer *et al*, 1997; Ockene *et al*, 2001). This probably is particularly the case for plasma levels of CRP and SAA, because these firstclass acute-phase reactants are the most sensitive plasma proteins that indicate inflammatory activity (Yamada, 1999). It has been suggested that multiple blood samplings of plasma fibrinogen and CRP are required to decrease the contribution of their intra-individual variation (de Maat *et al*, 1996; Ockene *et al*, 2001).

In conclusion, both the perception of job stress as biomarkers of inflammation and infection were measured with rather imprecise methods. As a result of this, the truly

existing associations have most likely been underestimated. Therefore, large prospective studies with multiple assessments of exposure and outcome measures are needed to explore possible associations in greater detail.

CHAPTER 4

The Impact of Psychosocial Factors on Low Back Pain - Longitudinal Results from the Belstress Study

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***Spine* 2007; Vol. 32: 262–268**

Abstract

Study Design. An epidemiological cohort study. *Objective*. To describe the impact of psychosocial factors, both work and nonwork-related, on the prevalence of low back pain (LBP) after 6.6 years on average. *Summary of Background Data*. There is growing consensus that psychosocial factors play a role in the development of LBP, although results are not consistent across studies. *Methods*. Within a sample of 2,556 middle-aged men and women from the Belstress study, baseline psychosocial factors were measured through self-administered questionnaires and related to prevalent cases of LBP after a mean time interval of 6.6 years through Cox regression analysis. *Results*. After adjustment for individual and physical risks, including occasional back pain at baseline, the prevalence rate of LBP in men was significantly related to baseline low decision latitude and low social support at work, and nonsignificantly to high job strain, low wage and job satisfaction, feeling stressed at work, and feeling depressed. High job insecurity, feeling stressed at work, and feeling depressed nonsignificantly increased the relative risks for LBP in women. *Conclusions*. Based on the results of this study, psychosocial factors (both work and nonwork-related) constitute nonnegligible risks for the development of LBP.

Introduction

Low back pain (LBP) is a considerable health problem in most Western countries. According to the Third European Survey on Working Conditions of 2000, 33% of European workers report backache, making it one of the most prevalent work-related health problems (Paoli & Merllié, 2000). Since most of the chronic low back disorders are believed to be multifactorial in origin, much research effort has been put in identifying different kinds of risk factors of LBP. The occurrence and development of LBP is not only ascribed to individual characteristics but also to factors from the work environment (Frank *et al*, 1995; Punnett & Wegman, 2004). Several biomechanical and physical work factors such as heavy lifting, repetitive motion, non-neutral body postures and vibration, are considered as established risks for back disorders.

There is growing consensus, however, that in addition to physical work load, psychosocial work characteristics play a role in LBP (Hoogendoorn *et al*, 2000; National research council - institute of medicine, 2001; Kerr *et al*, 2001; Linton, 2001). The most common work-related psychosocial constructs in epidemiological research include factors like workload, limited control over work, job satisfaction, feeling stressed, and relationships at work. Numerous studies have emphasized the need to take into account both physical and psychosocial characteristics simultaneously in epidemiological studies on LBP (Bigos *et al*, 1991; Lagerström *et al*, 1995; Skov *et al*, 1996; Hagen *et al*, 1998; Latza *et al*, 2002; IJzelenberg *et al*, 2004). Nevertheless, several reviews have shown that results regarding the role of psychosocial factors on LBP are not consistent across studies (Bongers *et al*, 1993; Burdorf & Sorock, 1997; Davis & Heaney, 2000; Hartvigsen *et al*, 2004). There is general agreement that some association exists, but it is difficult to draw firm conclusions due to inconclusive evidence. The inconsistency of study results is partly related to some crucial methodological issues, such as the study design, the assessment of exposure and outcome variables, and appropriate controlling for demographic and physical risk factors (Davis & Heaney, 2000).

The aim of this study is to describe the impact of psychosocial factors, both work- and nonwork-related, on the prevalence of LBP within a longitudinal study design. Secondly, we want to explore to what extent associations between psychosocial variables and LBP are confounded by individual and physical characteristics.

Materials and Methods

Study population

The association between psychosocial factors and LBP was assessed using data from the BELSTRESS study, an epidemiological cohort study about job stress and health issues (De Bacquer *et al*, 2005). A total of 2,821 workers from 9 different companies or public administrations were involved in the longitudinal part of the study. Data were gathered at baseline between 1995 and 1998 and a second time in 2002–2003 after a mean time interval of 6.6 years. A participation rate of 68.5% was reached at the second phase. For the longitudinal analyses described here, workers whose job title changed during the time interval according to the first digit of the International Standard Classification of Occupations (265 subjects) were excluded (ILO, 1990). This results in a study population of 2,556 workers (1,729 men and 827 women) aged 35–59 years at the beginning of the study. These workers are employed within 2 public administrations (55% of the sample), 6 private companies (34%), and one bank (11%).
The ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels approved the Belstress study.

Data collection

Psychosocial factors at baseline were measured through self-administered questionnaires. Most of the work-related factors were assessed using the standardized Job Content Questionnaire based on Karasek's job strain model (Karasek, 1979; Karasek, 1985; Karasek *et al*, 1998). Five items measured psychological job demands. Job control or decision latitude was composed of 2 subscales: "skill discretion" (6 items) and "decision authority" (3 items). The third dimension was social support at the workplace and also consisted of 2 subscales: "supervisor support" (4 items) and "co-worker support" (4 items). Reliability and validity of these scales within the Belstress study project have been demonstrated (Pelfrene *et al*, 2001). Perception of job insecurity was measured with 2 questions from the Job Content Questionnaire. In addition, the general questionnaire contained 3 items concerning job and wage satisfaction, and feeling stressed at work.
Three psychosocial factors outside the work environment were assessed through baseline questionnaires. The strength of social networks refers to a score based on 3

items regarding the number and nature of contacts with friends and family (Berkman & Syme, 1979). The concept of feelings of depression was composed of 11 items from the Center for Epidemiological Studies-Depression scale (Radloff, 1977). One question was added asking about the general satisfaction with private life.

The baseline questionnaire contained additional information on individual and physical characteristics that were treated as potential confounding variables. Data were gathered about age, educational level (low, medium, or high), living situation (alone or with partner), smoking status (current smokers vs. others), sector of employment (secondary, tertiary, or public sector), and physical activity outside work. Occasional back pain (yes vs. no) was assessed by one item from the "Current Health Index" ("Do you once in a while suffer from back pain?") (Dirken, 1969). Five Job Content Questionnaire items regarding physical demands of the job were included: physical effort, lifting heavy loads, rapid physical activity, awkward body positions, and awkward arm positions (Karasek, 1985). Trained observers medically examined participants at baseline. Body mass index (BMI) was calculated as body weight (kg) divided by the square of the height (m).

At the second data collection after a mean time interval of 6.6 years, prevalent cases of LBP were identified using the standardized Nordic questionnaire (Kuorinka *et al*, 1987). Participants were classified as having LBP when they had had LBP of any kind for a total of 8 days or more during the previous 12 months.

Statistics

All psychosocial risk factors were dichotomized. This categorization was based on the median values of this population for the scales of job demands (12), decision latitude (27), social support at work (23), and job insecurity (3). High job strain refers to the combination of high job demands (values above the median) and low decision latitude (values below the median). Low satisfaction with the job, wage, and private life refers to being (very) dissatisfied as opposed to neutral or (very) satisfied. Participants were classified as stressed at work when they felt moderately or very stressed. A strong social network was attributed when participants had regular contacts (at least once a month) with at least 5 close friends or family members. The upper quartile of the depression scale with scores of 18 or higher was considered to suffer from depressive feelings.

Low education was defined as primary school level only and high education as high school or university. Persons who engage in heavy physical activity (resulting in sweating and elevated pulse rate) during 20 minutes or more, at least once a week, were classified as physically active. High physical job demands were identified when respondents (fully) agreed with the questions regarding physical effort, lifting heavy loads, rapid physical activity, awkward body positions, and awkward arm positions at work. A BMI between 25 and 29 kg/m2 was classified as overweight and a BMI of 30 kg/m2 or more as obesity (World Health Organization, 2000).

Chi² tests were carried out to explore whether cases with LBP differed from noncases in individual and physical characteristics at baseline. Cox regression analyses were conducted in order to assess the impact of baseline psychosocial factors on LBP. Subsequently, it was tested to what extent these associations were confounded by other risk factors through multivariate analyses. Individual and physical factors were included in the full model, regardless of the results of their univariate associations with the outcome variable (Sun *et al*, 1996). Adjustments were made for individual and sociodemographic variables (age, BMI, educational level, sector of employment, occasional back pain, smoking status, and living situation) in the first step, and, additionally, for physical factors (physical activity, physical effort, lifting heavy loads, rapid physical activity, awkward body positions, and awkward arm positions at work) in the next step.

Analyses were performed separately for men and women. All analyses were conducted using SPSS 12.0 software (SPSS, Inc., Chicago, IL).

Results

The mean age of the sample at baseline was 43.6 years (SD 5.0). The population contained 441 executives (17%), 1,190 white-collar workers (47%), and 916 blue-collar workers (36%). Within the sample of 2,556 workers, 1,079 cases (42.2%) with LBP of any kind were identified at the second study phase. This prevalence rate of LBP was significantly higher in women as compared to men: 413 out of 827 women (49.9%) and 666 out of 1,729 men (38.5%) (P<0.001).

Individual and physical characteristics at baseline in cases and noncases are shown in Table 4.1. The prevalence of cases with LBP was higher in participants with a lower educational level, workers from the public sector, those with occasional back pain at baseline, smokers, and workers with high physical job demands. Women aged 45

years or more had more LBP than those who were younger. LBP was more frequent in men with overweight and obesity.

Crude associations between baseline psychosocial factors and the prevalence of LBP after a mean time interval of 6.6 years were assessed through Cox regression analyses (Table 4.2). The relative risk for LBP in men was significantly increased with 37% by baseline low decision latitude and with approximately one fifth by baseline high job strain, low social support at work, low wage satisfaction, and feeling stressed at work. A nonsignificant association was noted regarding low job satisfaction in men. Within the female population, nonsignificant associations were found with low decision latitude, high job insecurity, and feeling stressed at work. No clear associations in men or women were found with psychological job demands. Concerning psychosocial factors outside the work environment, LBP related primarily to feelings of depression at baseline, with an increase in the relative risk of 34% in men and 30% in women. In men, low satisfaction with private life also slightly increased the relative risk for LBP.

Within this study design, we could not exclude workers with LBP at baseline because the Nordic Questionnaire was not available. However, information was available regarding occasional back pain at baseline. Additional analyses within the subgroup of participants without occasional back pain at baseline showed associations between crude relative risks for LBP in men with low decision latitude (relative risk 1.49; confidence interval [CI] 1.07–2.09), high job strain (relative risk 1.21; CI 0.77–1.91), low social support (relative risk 1.48; CI 1.06–2.08), low job satisfaction (relative risk 1.57; CI 0.89–2.78), low wage satisfaction (relative risk 1.56; CI 1.02–2.38), feeling stressed at work (relative risk 1.15; CI 0.82–1.62), and feeling depressed (relative risk 1.34; CI 0.88 –2.03), while crude relative risks for LBP in women were associated with high job insecurity (relative risk 1.10; CI 0.70– 1.74), feeling stressed at work (relative risk 1.12; CI 0.70–1.78), and feeling depressed (relative risk 1.12; CI 0.67–1.88).

Table 4.1 Individual and physical characteristics at baseline in cases and noncases of LBP

Characteristics	Men			Women		
	No. Cases (n = 666)	No. Noncases (n = 1057)	χ^2	No. Cases (n = 413)	No. Noncases (n = 409)	χ^2
Age ≥45 yr	343 (51.5%)	527 (49.9%)	0.4	165 (40.0%)	135 (33.0%)	4.3*
Educational level			31.1‡			25.6‡
low	303 (46.0%)	358 (34.1%)		185 (44.9%)	124 (30.6%)	
medium	189 (28.7%)	307 (29.3%)		157 (38.1%)	160 (39.5%)	
high	166 (25.2%)	384 (36.6%)		70 (17.0%)	121 (29.9%)	
Sector of employment			5.2			17.9‡
secondary (manufacturing)	210 (31.5%)	378 (35.8%)		21 (5.1%)	32 (7.8%)	
tertiary (service)	126 (18.9%)	214 (20.2%)		66 (16.0%)	108 (26.4%)	
public	330 (49.5%)	465 (44.0%)		326 (78.9%)	269 (65.8%)	
Living alone	90 (13.6%)	141 (13.5%)	0.0	104 (25.3%)	89 (21.9%)	1.3
Occasional back pain	516 (78.5%)	425 (40.7%)	232.9‡	333 (81.2%)	212 (52.9%)	73.9‡
Current smokers	229 (34.7%)	309 (29.5%)	5.2*	135 (33.2%)	110 (27.5%)	3.1
BMI			12.0†			2.4
normal	233 (35.1%)	459 (43.5%)		248 (60.3%)	251 (61.4%)	
overweight	339 (51.1%)	470 (44.5%)		107 (26.0%)	116 (28.4%)	
obesity	92 (13.9%)	126 (11.9%)		56 (13.6%)	42 (10.3%)	
Physically active outside work	270 (43.1%)	437 (42.8%)	0.0	93 (23.7%)	77 (19.6%)	1.9
Physical effort: high	222 (34.0%)	270 (26.0%)	12.5‡	185 (45.6%)	116 (29.1%)	23.4‡
Lifting heavy loads: high	155 (23.9%)	167 (16.1%)	15.6‡	140 (34.5%)	92 (23.0%)	13.0‡
Rapid physical activity: high	146 (22.4%)	173 (16.7%)	8.4†	133 (33.1%)	84 (21.1%)	14.5‡
Awkward body positions: high	132 (20.3%)	128 (12.3%)	19.5‡	87 (21.7%)	47 (11.8%)	13.9‡
Awkward arm positions: high	105 (16.1%)	111 (10.7%)	10.6†	80 (20.1%)	39 (9.8%)	16.5‡

* $p<0.05$; † $p<0.01$; ‡ $p<0.001$

Table 4.2 Crude associations between baseline psychosocial factors and prevalent cases of LBP in men and women

	Men (n = 1,729)		Women (n = 827)	
Baseline psychosocial factors	RR	95% CI	RR	95% CI
Work-related				
High job demands*	0.92	0.79-1.07	0.94	0.77-1.15
Low decision latitude	**1.37**	1.17-1.59	1.12	0.91-1.38
High job strain†	**1.22**	1.00-1.49	1.05	0.83-1.32
Low social support	**1.23**	1.05-1.44	1.08	0.88-1.33
High job insecurity*	0.99	0.85-1.16	1.11	0.92-1.35
Low job satisfaction	1.19	0.89-1.58	0.85	0.53-1.36
Low wage satisfaction	**1.22**	1.00-1.49	1.02	0.76-1.36
Feeling stressed at work‡	**1.19**	1.02-1.39	1.18	0.97-1.43
Nonwork-related				
Low social network	0.88	0.75-1.03	1.04	0.85-1.27
Feeling depressed‡	**1.34**	1.12-1.60	**1.30**	1.06-1.58
Low satisfaction with private life	1.12	0.84-1.49	1.02	0.77-1.37

Results from Cox regression analysis; Reference categories are "high" unless stated otherwise; Significant relative risks at the 0.05 level are in bold; *Reference category is "low"; †Reference category is "others"; ‡Reference category refers to not feeling stressed or depressed; CI indicates confidence interval; RR, relative risk

In multivariate Cox regression analyses, individual and physical risk factors were included in the full model (Table 4.3). Overall, most relationships between psychosocial factors and LBP were not essentially mediated by individual or physical variables. After adjustment for individual, sociodemographic, and physical risks, the relative risk for LBP in men was significantly increased by baseline low decision latitude (relative risk 1.20) and low social support at work (relative risk 1.20). In men, a borderline significant association was found with feeling stressed at work, and nonsignificant associations with high job strain, low job and wage satisfaction, and feeling depressed. The relative risk for LBP in women was borderline significantly increased by feeling depressed, and nonsignificantly by high job insecurity and feeling stressed at work.

Significant crude associations between LBP and baseline physical job demand items were identified in men and women, with relative risk ratio's ranging from 1.24 to 1.43 (Table 4.4). After adjustment for individual and sociodemographic variables, nonsignificant associations were found with awkward body positions in men and awkward arm positions in women. No interaction effects were found between psychosocial factors and physical job demands in relation to LBP. Controlling for physical work factors did not reduce the strength of the associations between psychosocial factors and LBP extensively.

Table 4.3 Adjusted associations between baseline psychosocial factors and prevalent cases of LBP in men and women

	RR (95% CI)§		RR (95% CI)‖	
Baseline psychosocial factors	Men (n = 1,729)	Women (n = 827)	Men (n = 1,729)	Women (n = 827)
Work-related				
High job demands*	1.00 (0.85-1.18)	0.99 (0.81-1.23)	1.00 (0.84-1.20)	0.97 (0.78-1.21)
Low decision latitude	**1.22** (1.03-1.44)	0.96 (0.76-1.20)	**1.20** (1.01-1.42)	0.96 (0.76-1.21)
High job strain†	1.13 (0.92-1.39)	1.02 (0.80-1.29)	1.13 (0.91-1.40)	0.99 (0.77-1.27)
Low social support	**1.17** (1.00-1.38)	1.01 (0.82-1.25)	**1.20** (1.02-1.42)	1.00 (0.80-1.24)
High job insecurity*	1.03 (0.87-1.21)	1.09 (0.89-1.34)	1.02 (0.86-1.21)	1.09 (0.87-1.37)
Low job satisfaction	1.11 (0.83-1.50)	0.80 (0.49-1.31)	1.10 (0.81-1.49)	0.79 (0.47-1.33)
Low wage satisfaction	1.15 (0.94-1.41)	1.00 (0.74-1.35)	1.14 (0.92-1.41)	1.03 (0.76-1.41)
Feeling stressed at work‡	**1.19** (1.01-1.39)	1.11 (0.91-1.36)	1.17 (0.99-1.38)	1.09 (0.88-1.35)
Nonwork-related				
Low social network	0.90 (0.77-1.06)	1.05 (0.86-1.30)	0.93 (0.78-1.10)	1.05 (0.84-1.31)
Feeling depressed‡	1.15 (0.96-1.38)	1.18 (0.96-1.46)	1.11 (0.91-1.34)	1.21 (0.97-1.50)
Low satisfaction with private life	1.03 (0.76-1.40)	1.03 (0.75-1.40)	0.99 (0.72-1.37)	1.04 (0.75-1.44)

Results from Cox regression analysis; Reference categories are “high” unless stated otherwise; Significant relative risks at the 0.05 level are in bold; *Reference category is “low”; †Reference category is “others”; ‡Reference category refers to not feeling stressed or depressed; §Adjusted for age, BMI, educational level, sector of employment, occasional back pain, smoking status, and living situation; ‖Additionally adjusted for physical activity, physical effort, lifting heavy loads, rapid physical activity, awkward body positions, and awkward arm positions at work

Table 4.4 Crude and adjusted associations between baseline physical job demands and prevalent cases of LBP in men and women

	RR (95% CI)		RR (95% CI)*	
Baseline physical job demands	Men (n = 1,729)	Women (n = 827)	Men (n = 1,729)	Women (n = 827)
Physical effort: high	**1.26** (1.07-1.48)	**1.40** (1.15-1.70)	1.02 (0.86-1.22)	1.14 (0.91-1.43)
Lifting heavy loads: high	**1.33** (1.11-1.59)	**1.30** (1.06-1.60)	1.10 (0.90-1.34)	1.08 (0.86-1.35)
Rapid physical activity: high	**1.24** (1.03-1.49)	**1.33** (1.08-1.64)	0.99 (0.82-1.21)	1.10 (0.87-1.39)
Awkward body positions: high	**1.40** (1.16-1.70)	**1.37** (1.08-1.74)	1.16 (0.95-1.41)	1.12 (0.86-1.44)
Awkward arm positions: high	**1.31** (1.06-1.62)	**1.43** (1.12-1.83)	1.06 (0.86-1.32)	1.21 (0.94-1.57)

Results from Cox regression analysis; Reference categories are “low”; Significant relative risks at the 0.05 level are in bold; *Adjusted for age, BMI, educational level, occasional back pain, smoking status and living situation; CI indicates confidence interval; RR, relative risk

Discussion

The aim of this longitudinal study was to explore the impact of psychosocial risk factors on LBP. Within a sample of 2,556 middle-aged men and women, psychosocial factors at baseline were related to the prevalence of cases with LBP after a mean time interval of 6.6 years. Although there is mounting support for the importance of psychosocial factors in the etiology of LBP, some recent reviews have emphasized the uncertainty of the exact relationship due to the lack of consistency in study results (Davis & Heaney, 2000; Hartvigsen *et al*, 2004).

Based on the results of this study, psychosocial factors constitute nonnegligible risks for LBP. Moreover, most associations were independent from occasional back pain at baseline, as well as from other individual and physical risk factors. Among the psychosocial work characteristics, one of the significant and independent predictors of LBP in men was baseline low social support at work. Several studies reported that the most consistent and pronounced associations with back pain were situated in the field of worksite social support (Leino & Hanninen, 1995; Lagerström *et al*, 1995; Skov *et al*, 1996; Toomingas *et al*, 1997; Hoogendoorn *et al*, 2001; Yip, 2004). In reviewing prospective studies on psychosocial work characteristics and LBP, Hoogendoorn *et al* (2000) found strong evidence for low social support in the workplace as a risk factor. After adjustments were made for individual and physical factors, the prevalence of LBP in men was also significantly related with low decision latitude, and nonsignificantly with high job strain, low job and wage satisfaction, and feeling stressed at work. Substantial heterogeneity exists in the literature regarding the role of low job control and low job satisfaction in LBP. Although some reviews found support for a positive association between these factors and LBP (Burdorf & Sorock, 1997; Hoogendoorn *et al*, 2000; Linton, 2001), others contradicted this (Bongers *et al*, 1993; Hartvigsen *et al*, 2004). It has been suggested that the influence of psychosocial factors on LBP may not be solely related to work itself but also to the broader nonwork-related context; therefore, it is also important to take into account work-related perceptions such as satisfaction with work status and income and job stress in trying to understand the development of LBP (Bigos *et al*, 1991; Papageorgiou *et al*, 1998; Fishbain, 2000). In their review on psychosocial work factors and LBP, Davis & Heaney (2000) suggested that the most consistent associations were not found with psychosocial work characteristics themselves but with employee responses or reactions to their work conditions. In our longitudinal study, the prevalence of LBP was both related to psychosocial work

characteristics themselves (low decision latitude and low social support in men and high job insecurity in women), as to employee reactions to work conditions (low job and wage satisfaction in men and feeling stressed at work in men and women).

When assessing associations between psychosocial factors and LBP, the emphasis in most studies is on characteristics related solely to the work environment. However, psychosocial factors outside the work environment may also play an important role in the development of LBP. Conditions in leisure time such as satisfaction with social contacts can exert a long-term influence on LBP (Thorbjörnsson *et al*, 1998). Conditions of psychological or emotional distress, including depressive feelings and anxiety, have also been related to musculoskeletal disorders and LBP (Adams *et al*, 1999; Grossi *et al*, 1999). In this study, associations were found between feeling depressed and the prevalence of LBP.

Some notable gender differences were found in our study. Overall, psychosocial work factors proved to be important with respect to LBP, but to a lesser extent in women as compared to men. Similar results were found in various other studies (Foppa & Noack, 1996; Papageorgiou *et al*, 1997; Barnekow-Bergkvist *et al*, 1998; Vingard *et al*, 1999). Hooftman *et al* (2004) recently reviewed 14 studies regarding gender differences in the effect of risk factors on back complaints. With respect to the effect of job demands, job control, and job satisfaction, the evidence for gender differences is inconclusive due to inconsistent results. No evidence was found of a gender difference in the impact of social support at the workplace, which is not in line with the results of this study.

An important problem in many studies exploring the impact of psychosocial factors on LBP is the lack of proper adjustment for other risk factors, especially physical or biomechanical workload (Hoogendoorn *et al*, 2000; Davis & Heaney, 2000). In our study, however, relationships between psychosocial factors and future LBP were not essentially confounded by individual or physical variables. This was also found in a Dutch prospective cohort study in 861 workers (Hoogendoorn *et al*, 2001).

The assessment of LBP in this study was not done through clinical examination but with a self-report measure, which inevitably includes some amount of subjectivity. Nevertheless, random error in the operationalization of LBP was minimized because of the use of the validated and standardized Nordic questionnaire for musculoskeletal symptoms (Kuorinka *et al*, 1987). LBP in this study was identified as having had LBP for a total of 8 days or more during the previous 12 months, which is very common. The same analyses were conducted with a more stringent definition: having had LBP for a total of 30 days or more during the previous 12 months (prevalent in 21.4% of men and

32.8% of women). This led to similar results, although some of the associations did not reach statistical significance.

Since the Nordic questionnaire was not included in the baseline questionnaire, it was not feasible to conduct prospective analyses on the subsample with no LBP at baseline. However, information was available regarding occasional back pain at baseline. With the inclusion of this variable in multivariate analyses, it is fair to assume that the largest part of LBP at baseline was controlled for. Moreover, additional analyses after exclusion of all participants with occasional back pain at baseline roughly engendered similar results regarding psychosocial factors and LBP.

A notable limitation of this study is that no information is available on possible changes in exposure to psychosocial factors between baseline and the assessment of LBP at the second study phase. This is of particular importance because of the relatively long time interval of 6.6 years on average. Participants whose job title changed during the time interval were excluded. This was done in order to rule out changes in psychosocial work factors due to objective changes in the work environment. Nevertheless, this does not mean that psychosocial or physical work characteristics may not have altered within the same job title. In addition, measuring job characteristics at only one point in time increases the risk of misclassification due to inaccuracy in assessment (Landsbergis *et al*, 2002). Consequently, the relationships found in our study are probably underestimations or at least conservative estimates of the truly existing associations between psychosocial factors and the development of LBP.

The presence of a selection bias in the population should be taken into consideration when interpreting the results. For the longitudinal results of this study, only those workers who were involved in both phases of the data collection were included. Within the 9 participating companies, a total of 8,783 employees had participated in the first study phase. At the second study phase, more than half of this original population was no longer eligible due to retirement, resignation, dismissal, or decease. It concerned primarily workers from lower educational levels, lower occupations, and older age groups. Within 3 companies from the secondary or manufacturing sector, major reorganizations and restructuring measures had been carried out, as a result of which 73% of the original study sample was no longer at work there after the follow-up period. Some important reorganizations had also taken place within 4 companies from the service sector; 47% of the population was no longer eligible for participation. Within 2 public administrations, 33% was no longer eligible, which was mostly due to natural retirements. Obviously, this resulted in a healthy-worker effect within our population. At

baseline, the “drop-out” population perceived significantly less job control. In addition, severe LBP at baseline might also be related to the “drop-out.” Consequently, associations between psychosocial factors and LBP in this study are most likely underestimated.

Conclusions

Our results provide additional support to the findings linking LBP to psychosocial risk factors. Both work and nonwork-related psychosocial factors were associated with having LBP after 6.6 years on average within a sample of 2,556 middle-aged men and women who remained in the same job. Moreover, the associations were independent from some important individual and physical risk factors, including occasional back pain at baseline.

CHAPTER 5

Job Stress and Depression Symptoms in Middle-Aged Workers – Prospective Results from the Belstress Study

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***Scandinavian Journal of Work, Environment & Health* 2007; In Press**

Abstract

Objective. The aim of this study was to explore the prospective relation between job stress and depression symptoms within a cohort study. *Methods*. A total number of 2,821 workers were involved in the longitudinal Belstress study; there were two measurements with a mean follow-up time of 6.6 years. Job stress was assessed by the Job Content Questionnaire. Depression symptoms were assessed by the Iowa form of the Center for Epidemiological Studies-Depression scale. Baseline and repeated exposure to job stress were related to developing high levels of depression symptoms through logistic regression analysis. *Results*. Within a population free of high depression scores at baseline, job stress increased the risk for developing high levels of depression symptoms after a mean follow-up time of 6.6 years. Independent associations were found for low decision latitude, high job strain, and isolated strain in women, but not in men. The adjusted association with high job strain in men was borderline significant. Repeated high job strain was associated with more elevated risk of developing high levels of depression symptoms in both women and men. *Conclusions*. The results of this study confirm that job stress is a risk factor for developing depression symptoms. Stronger associations were found in women. The impact of high job strain in both men and women was more harmful when there was repeated exposure.

Introduction

There is general agreement about the multi-factorial etiology of mental health disorders. Affective disorders are believed to be psychosocial by nature, with a complex interweaving of both social and psychological characteristics (Harris, 2001). During the last decennia, more and more attention has been given to the role of the working environment in determining people's mental health condition. According to the Third European survey on Working Conditions conducted in 2000, the majority of European workers consider that their work affects their health; psychological distress represents a substantial part of these work-related health problems (Paoli & Merllié, 2000).

The most influential and widely used model in occupational health research is the Demand – Control - Support (DCS) model developed by Karasek in the seventies (Karasek, 1979; Johnson & Hall, 1988; Karasek *et al*, 1998). According to this model, adverse health effects are expected when workers are exposed to high psychological demands in combination with low decision latitude or job control, which is labeled as 'high job strain'. The 'iso-strain' hypothesis states that people with high strain and low social support at work, labeled as 'isolated strain', are most vulnerable to negative health effects.

In general, results on job strain and psychological well-being are not consistent across studies (Van Der Doef & Maes, 1999). Support for an association is mainly found in cross-sectional studies, while longitudinal studies are rather scarce and provide less support. In a number of cross-sectional studies, adverse working conditions have been related with poor mental health outcomes (Karasek, 1979; Landsbergis, 1988; Stansfeld *et al*, 1995; Bourbonnais *et al*, 1996; Bourbonnais *et al*, 1998; Moisan *et al*, 1999; De Jonge *et al*, 2000; Mausner-Dorsch & Eaton, 2000; Calnan *et al*, 2000; Vermeulen & Mustard, 2000; Wang & Patten, 2001; Tsutsumi *et al*, 2001a; Godin & Kittel, 2004; Parslow *et al*, 2004; Sanne *et al*, 2005; Laaksonen *et al*, 2006). These studies however can not give an indication regarding the causal nature of the relation.

As far as longitudinal studies are concerned, prospective associations between job stressors and adverse mental health conditions were found in some studies with rather small sample sizes (Kawakami *et al*, 1992; Mino *et al*, 1999; Shigemi *et al*, 2000; Bildt & Michelsen, 2002; de Lange *et al*, 2004) and in a few large-scale studies (Kawakami *et al*, 1990; Niedhammer *et al*, 1998), while negative results were reported in one study (Carayon, 1993). Within the Whitehall II study comprising more than 7000 participants,

work characteristics predicted several mental health outcomes (Stansfeld *et al*, 1997; Stansfeld *et al*, 1998; Stansfeld *et al*, 1999; Griffin *et al*, 2002). A meta-analysis of 11 longitudinal studies provided evidence that the psychosocial work environment is a prospective risk factor for common mental disorders (Stansfeld & Candy, 2006). Results in prospective studies are usually based upon a single assessment of job stressors. Only few studies examined multiple measurements of job stressors and found cumulative exposure of job stressors to be an important predictor of mental health indicators (Bourbonnais *et al*, 1999; de Lange *et al*, 2002; Godin *et al*, 2005).
Within the first phase of our Belstress study including more than 21,000 middle-aged workers, several aspects of psychological well-being were cross-sectionally associated with job stress according to the DCS model (Pelfrene *et al*, 2002b; Pelfrene *et al*, 2004). In the longitudinal part of the Belstress study, we want to explore the prospective relation between job stress and depression symptoms within a cohort study. The first objective is to describe prospectively the impact of job stress according to the DCS model on the development of depression symptoms. The second objective is to relate repeated exposure to job strain with depression symptoms. We hypothesize that the impact of job strain on depression symptoms is even more harmful when there is consistent exposure measurement. Our study is the first to examine both single and repeated exposure to job strain in relation to depression symptoms in a long-term perspective.

Methods

Study population

The association between job stress and depression symptoms was assessed using data from the BELSTRESS study, an epidemiological cohort study about job stress, cardiovascular and other health issues and sick leave (Moreau *et al*, 2004; De Bacquer *et al*, 2005). A total number of 2,821 workers from 9 different companies or public administrations were involved in the longitudinal part of the study. All workers aged 35 - 59 years within the companies were invited to participate. Data were gathered at baseline between 1995 and ’98 (Time 1), and a second time in 2002-’03 (Time 2) after a mean follow-up time of 6.6 years (SD = 1.13; range = 4 years). A participation rate of 67.2% was reached at the second phase. The population contained 1,950 men and 871 women aged 35 - 59 years at the beginning of the study. These workers were

employed within 2 public administrations (55% of the sample), 6 private companies (34%) and 1 bank (11%). The sample included 500 executives (18%), 1,291 white-collar workers (46%) and 997 blue-collar workers (36%).
The Belstress study was approved by the ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels.

Data collection

At both Time 1 and Time 2, participants completed a self-administered questionnaire. Job stress was assessed using the standardized Job Content Questionnaire (JCQ), based on Karasek's DCS model (Karasek, 1985). Psychological job demands were composed of the sum score (range 5 – 20) of five items that relate to mental work load, organization constraints on task completion and conflicting demands (e.g. "my job requires working very hard" and "I have enough time to get the job done"). Job control or decision latitude was composed of the sum score (range 9 – 36) of two subscales: 'skill discretion' or the level of skill and creativity required on the job (sum score of six items, e.g. "my job requires a high skill level" and "my job requires that I learn new things") and 'decision authority' or the possibilities for workers to make decisions about their work (sum score of three items, e.g. "my job allows me to make a lot of decisions on my own" and "I have a lot of say about what happens on my job"). The third dimension of social support at the workplace also consisted of the sum score (range 8 – 32) of two subscales: 'supervisor support' (sum score of four items, e.g. "my supervisor pays attention to what I am doing" and "my supervisor is helpful in getting the job done") and 'co-worker support' (sum score of four items, e.g. "people I work with take a personal interest in me" and "people I work with are friendly"). All JCQ items had four response categories (1-4, with 1 "fully disagree" and 4 "fully agree"). The JCQ has been proven a valid and reliable tool to measure job stressors (Karasek *et al*, 1998); this was also confirmed within the first Belstress study (Pelfrene *et al*, 2001). Dichotomous variables (low versus high) were created for demands, control and support, based on the median values (12 for demands, 27 for control and 23 for support). High job strain refers to the combination of high job demands and low decision latitude. Iso-strain or isolated strain was defined as high job strain combined with low social support. These categories were compared to all other possible combinations in order to test the (iso-) strain hypothesis of the model.

The Center for Epidemiological Studies-Depression scale is a standardized tool to measure symptoms of depression (Radloff, 1977). In this study, we used the shorter Iowa form with 11 items, whose reliability and validity has been shown (Kohout *et al*, 1993; Carpenter *et al*, 1998). Example items are "I felt depressed during the last two weeks" and "I felt lonely during the last two weeks". The items had three response categories (1-3, with 1 "rarely or never" and 3 "most of the time"). Symptoms of depression were calculated as the sum score of the 11 items (range 11 - 33). In the original 20-item Center for Epidemiological Studies-Depression scale, a cut-point of 16 is commonly used to indicate high depression symptoms, which corresponds to the 80th percentile of scores in community samples (Kohout *et al*, 1993; Carpenter *et al*, 1998). Therefore we have chosen to consider those with scores of 19 or higher as reporting high levels of depression symptoms, corresponding to the 80th percentile in our sample. Information was gathered on possible confounding variables. To begin with, we wanted to take some essential socio-demographic factors into account; the baseline questionnaire provided data concerning age (35-44 years or 45-59 years) and educational level (low, medium or high). In addition, we included social network (low or high) and satisfaction with private life (low or high) in the analyses because several studies have demonstrated the importance of private life factors next to work characteristics in relation to mental health (Schwartzberg & Dytell, 1996; Griffin *et al*, 2002). Finally, the personality factor locus of control has also been associated with psychological well-being and was controlled for in our analyses (Parkes, 1991; Daniels & Guppy, 1994). Two items ("I can do little to change important things in my life" and "what happens in the future depends largely on myself") with four response categories (1-4, with 1 "fully disagree" and 4 "fully agree") were included to measure locus of control (sum score, range 2 - 8). Respondents with scores of six or higher were considered to have an external locus of control. These are people who believe they have no or few power to change things in their lives or to determine what will happen in the future. Low education was defined as primary school level only; high education as high school or university. The strength of social networks refers to a score based on three items regarding the number and nature of contacts with friends and family (Berkman & Syme, 1979). A high or strong social network was attributed when participants have regular contacts (at least once a month) with at least 5 close friends or family members. One question was added asking about the general satisfaction with private life ("how satisfied are you with your private life?"). Low satisfaction referred to being (very) dissatisfied as opposed to neutral or (very) satisfied.

Statistical analyses

Job stress at baseline was related to depression symptoms after a mean follow-up time of 6.6 years. For these prospective analyses, participants with high depression symptoms at baseline were excluded. We excluded cases with high levels of depression symptoms (scores of 19 or higher) and cases with missing value for this variable at baseline, resulting in a population of 2,139 participants.

Chi² tests were performed in order to explore whether job stress and possible confounding variables at baseline were univariately associated with depression symptoms at Time 2. The independent impact of job stress on depression symptoms was assessed through multivariate logistic regression analysis. All variables were entered in a single step. Adjustments were made for age, educational level, social network, satisfaction with private life and locus of control, regardless of the results of their univariate associations with the outcome variable (this was done to avoid incorrect rejection of potentially important variables) (Sun *et al*, 1996). We also controlled for the Time 1 score of depression symptoms. The interaction effects for job demands by job control and for job strain by social support in relation to depression symptoms were assessed.

Repeated high job strain and repeated isolated strain were related to depression symptoms at Time 2 through logistic regression analysis. Four groups were created: those with high job strain or isolated strain at both observation times, those not exposed to high job strain or isolated strain at either observation, those with high job strain or isolated strain only at Time 1 and those with high job strain or isolated strain only at Time 2.

Analyses were performed separately for men and women because associations between work factors and psychological well-being have generally shown to be unequal in both sexes (Van Der Doef & Maes, 1999; Stansfeld & Candy, 2006). All analyses were conducted using SPSS 12.0 software.

Results

Sample characteristics at baseline are shown in Table 5.1.

Table 5.1 Sample characteristics at baseline (n = 2,821)

	Men (n = 1,950)[a]		Women (n = 871)[b]	
	n	%	n	%
Educational level				
Low	739	37.9	320	36.7
Medium	554	28.4	330	37.9
High	638	32.7	214	24.6
Low social network	929	47.6	489	56.1
Low satisfaction with private life	135	6.9	105	12.1
External locus of control	533	27.3	225	25.8
High level of depression symptoms	390	20.0	309	35.5
High job demands	923	47.3	351	40.3
Low decision latitude	782	40.1	529	60.7
High job strain	300	15.4	196	22.5
Low social support	823	42.2	360	41.3
Isolated strain	190	9.7	107	12.3

[a] mean age = 43.7 (SD 5.0); [b] mean age = 42.8 (SD 5.0)

Within the sample of 2,139 workers free of high levels of depression symptoms at baseline, 252 cases (11.8%) with high levels of depression symptoms were identified at Time 2. This proportion of newly developed depression symptoms was significantly higher in women as compared to men: 113 out of 571 women (19.8%) and 139 out of 1568 men (8.9%) (P<0.001). Several baseline job stress and confounding variables were associated with Time 2 depression symptoms (Table 5.2). Men and women in the high job strain and isolated strain groups developed significantly more depression symptoms at Time 2 than others. Depression symptoms were significantly associated with low decision latitude in women and with high job demands and low social support in men. Significant associations were also found with low satisfaction with private life, as well as with low social network and external locus of control in men.

Table 5.2 Univariate associations between baseline characteristics and depression symptoms at Time 2 (n = 2,139)

	High level of depression symptoms at Time 2					
Baseline	Men (n = 1,568)			Women (n = 571)		
characteristics	n	%	χ^2 (*P*)	n	%	χ^2 (*P*)
Job demands			4.31 (0.04)			1.18 (0.28)
Low	60	7.6		62	19.1	
High	78	10.6		48	23.0	
Decision latitude			2.40 (0.12)			10.98 (0.00)
Low	60	10.5		84	25.8	
High	78	8.2		29	13.8	
High job strain			11.72 (0.00)			7.89 (0.01)
No	105	8.0		76	18.4	
Yes	32	15.3		34	30.6	
Social support			7.54 (0.01)			3.00 (0.08)
Low	70	11.6		51	24.6	
High	66	7.4		56	18.3	
Isolated strain			10.42 (0.00)			14.45 (0.00)
No	117	8.4		87	18.7	
Yes	21	17.1		24	40.0	
Age			0.64 (0.43)			0.02 (0.88)
35 - 44 years	69	8.5		75	20.4	
45 - 59 years	70	9.7		38	21.0	
Educational level			0.68 (0.71) [a]			1.40 (0.50) [a]
Low	54	9.8		42	23.0	
Medium	39	8.7		44	20.3	
High	45	8.4		26	17.7	
Social network			5.61 (0.02)			0.11 (0.74)
Low	73	10.6		58	20.5	
High	54	7.1		45	19.3	
Satisfaction private life			11.70 (0.00)			4.89 (0.03)
Low	12	22.2		12	35.3	
High	126	8.6		99	19.5	
Locus of control			18.69 (0.00)			0.17 (0.68)
Internal	79	7.2		76	19.6	
External	58	14.5		26	21.3	

Number of degrees of freedom is 1 unless stated otherwise; [a] number of degrees of freedom is 2

The independent impact of job stress on depression symptoms was assessed trough multivariate logistic regression analysis (Table 5.3). In women, high levels of Time 2 depression symptoms were significantly associated with Time 1 low decision latitude. High job strain increased the risk for depression symptoms; this association was significant in women and borderline significant in men (*P*=0.06). In women, the risk was more than doubled by isolated strain.

None of the interaction terms for demands by control and for strain by support in relation to depression symptoms were significant.

Table 5.3 Adjusted associations between baseline job stress and depression symptoms at Time 2 (n = 2,139)

Baseline job stress	High level of depression symptoms at Time 2 OR (95% CI)[a]	
	Men (n = 1,568)	Women (n = 571)
Job demands		
Low	1	1
High	1.31 (0.87-1.99)	1.18 (0.72-1.94)
Decision latitude		
High	1	1
Low	1.07 (0.71-1.62)	**1.90** (1.08-3.33)
High job strain		
No	1	1
Yes	1.58 (0.98-2.54)	**1.74** (1.00-3.01)
Social support		
High	1	1
Low	1.03 (0.69-1.54)	1.35 (0.82-2.23)
Isolated strain		
No	1	1
Yes	1.52 (0.86-2.67)	**2.53** (1.32-4.86)

OR=odds ratio; CI=confidence interval; Significant relative risks at the 0.05 level are in bold; [a] adjusted for age, educational level, social network, satisfaction with private life, locus of control and Time 1 score of depression symptoms

Results for repeated high job strain and repeated isolated strain in relation to Time 2 depression symptoms are shown in Table 5.4. Men and women with repeated high job strain had the highest incidence of depression symptoms compared to those not in the high strain group at either Time 1 or Time 2. Those with unstable measurements showed intermediate levels of risk. The same pattern was found for repeated isolated strain in men, but not in women.

Table 5.4 Adjusted associations between repeated high job strain / isolated strain and depression symptoms at Time 2 (n = 2,139)

Repeated high job strain (number of men and women in the category)	High level of depression symptoms at Time 2 OR (95% CI)[a]	
	Men (n = 1,568)	Women (n = 571)
No – No (1183 men and 328 women)	1	1
Yes – No (136 men and 72 women)	1.25 (0.67-2.34)	1.50 (0.73-3.07)
No – Yes (118 men and 85 women)	**2.13** (1.16-3.93)	**2.14** (1.07-4.31)
Yes – Yes (70 men and 35 women)	**3.31** (1.67-6.56)	**3.40** (1.45-7.94)
Repeated isolated strain (number of men and women in the category)		
No – No (1323 men and 421 women)	1	1
Yes – No (96 men and 43 women)	1.07 (0.52-2.20)	**3.16** (1.47-6.78)
No – Yes (85 men and 48 women)	**3.14** (1.67-5.90)	**3.04** (1.35-6.82)
Yes – Yes (25 men and 15 women)	**5.80** (2.12-15.85)	2.12 (0.54-8.31)

OR=odds ratio; CI=confidence interval; Significant relative risks at the 0.05 level are in bold; [a] adjusted for age, educational level, social network, satisfaction with private life, locus of control and Time 1 score of depression symptoms

Discussion

The aim of this cohort study was to explore the prospective relation between job stress and depression symptoms. Within a population of 2,139 middle-aged workers free of high levels of depression symptoms at baseline, job stress increased the risk for developing high levels of depression symptoms after a mean follow-up time of 6.6 years. Significant independent associations were found for low decision latitude, high job strain and isolated strain in women. In men, the association with high job strain was borderline significant. This generally confirms results from longitudinal studies in which work factors were causally related to well-being (de Lange *et al*, 2003). Our results are in line with findings from a few large-scale prospective studies, the Whitehall II and Gazel study, in which job stressors according to the DCS model were related to mental health (Stansfeld *et al*, 1997; Niedhammer *et al*, 1998; Stansfeld *et al*, 1998; Stansfeld *et al*, 1999). The main hypotheses of the DCS model were confirmed in women; high job strain and isolated strain increased the risk for developing depression symptoms. None of the interaction terms for demands by control and for strain by support in relation to depression symptoms were statistically significant, which is in line with findings from a large number of studies (Landsbergis, 1988; Carayon, 1993; Stansfeld *et al*, 1995; Bourbonnais *et al*, 1996; Bourbonnais *et al*, 1998; Niedhammer *et al*, 1998; Van Der Doef & Maes, 1999; Moisan *et al*, 1999; Stansfeld *et al*, 1999; De Jonge *et al*,

2000; Vermeulen & Mustard, 2000; Wang & Patten, 2001; Pelfrene *et al*, 2002b; de Lange *et al*, 2003; Pelfrene *et al*, 2004; Sanne *et al*, 2005). The recent meta-analysis of 11 prospective studies on common mental disorders provided consistent robust evidence for causal effects for high job strain, while demands, control and support were associated with moderate risk (Stansfeld & Candy, 2006). Our findings are in line with this, although a significant independent association was also found for low decision latitude in women.

Prospective studies in the stress and health research field usually base their results on a single assessment of job stress. However, measuring job characteristics at only one point in time increases the risk of misclassification due to inaccuracy in assessment (Landsbergis *et al*, 2002). As a result, the relationships reported here are likely underestimations or at least conservative estimates of the truly existing associations. Only few studies examined multiple measurements of job stressors in relation to mental health. In a two-year study including 1,378 nurses, cumulative exposure to job strain was associated with the highest level of psychological distress (Bourbonnais *et al*, 1999). SMASH, the four-wave prospective cohort study with observations in 1,477 employees concluded that workers in the stable high strain group reported the highest level of depression (de Lange *et al*, 2002). The Somstress study conducting repeated measure with a one-year interval in 1,986 workers, found that employees with continuous effort-reward imbalance were at highest risk of developing poor mental health (Godin *et al*, 2005). Our results with repeated measures in a long-term perspective confirm that men and women with repeated high job strain and men with repeated isolated strain showed the highest incidence of depression symptoms. Due to the small number of observations, it is difficult to draw conclusions about repeated isolated strain and depression symptoms in women; only three women from the repeated isolated strain group reported high levels of depression symptoms. The impact of high job strain on depression symptoms was considerably larger when the exposure was repeated than when only baseline exposure was taken into account. Thus, based on these results, we highly recommend performing multiple measurements of job stressors. Multiple measurements result in a more reliable assessment and help avoid large underestimations of the true associations. A similar conclusion was drawn regarding single versus consistent exposure measures of job strain in relation to coronary heart disease in the Whitehall II study (Kivimaki *et al*, 2006a).

Unfortunately, no information on possible changes in job stress during the time lag between the two measurements was available in this study. First, there is the possibility of changes in job stress due to objective changes in job title. Additional analysis (data not shown, but available from the first author) after exclusion of participants whose job title changed between Time 1 and Time 2 engendered very similar results. On the other hand, psychosocial work characteristics may have altered within the same job title. As a result, our findings regarding the impact of repeated job strain might be underestimated. In addition, some of the confounding variables may also have changed between the two measurements.

Both job stress and depression symptoms were assessed by means of self-report measures. It is commonly assumed that relationships between variables measured with the same method, usually self-reports, are inflated due to common method variance. However, Spector (2006) recently suggested that the automatic criticism of self-reports along with the postulation that method alone is sufficient to produce biases have become an urban legend. Based on empirical evidence, features such as social desirability should not be considered as general or automatic sources of common method variance when self-reports are used. Furthermore, subjectivity bias in the self-report measures was reduced by using validated and standardized scales for the assessment of job stress (Karasek *et al*, 1998) and mental health (Kohout *et al*, 1993; Carpenter *et al*, 1998) in this study.

A fundamental strength of our study is its prospective design, which considerably increases the probability of a causal relation between job stress and depression symptoms. By excluding participants with high levels of depression symptoms at baseline, and furthermore adjusting for Time 1 score of depression symptoms, an appropriate prospective design was assured. It should be noted though, that those with low or intermediate levels of depression symptoms at baseline might have had higher scores in the past, which may have influenced their perception of job stress at Time 1.

Another methodological issue is the proper adjustment for confounding variables. The relationships in our study were controlled for some essential individual and socio-demographic factors: age and educational level. Some studies have emphasized the importance of integrating factors from the private family sphere beside work characteristics (Schwartzberg & Dytell, 1996; Griffin *et al*, 2002). Social network and satisfaction with private life were included in our analyses. It has been suggested that personality factors such as negative affectivity or neuroticism might confound the association between work stressors and mental health (Tennant, 2001). Unfortunately,

this kind of information was not available in our study. However, when these variables are controlled for in prospective studies, occupational stressors generally remain as independent predictors of mental health indicators (Stansfeld *et al*, 1999; Tennant, 2001). Locus of control has also been associated with psychological well-being and with the relation between stressors and mental health (Parkes, 1991; Daniels & Guppy, 1994). This variable was controlled for in our analysis.

A notable limitation is the presence of a selection bias in our population. Only those workers who were involved in both Time 1 and Time 2 measurements were included. Within the nine participating companies, 8,783 employees participated in the first round of data collection. At Time 2, more than half of this original sample was no longer eligible due to regular or premature retirement, resignation, dismissal or decease. Some companies had undergone major reorganizations with subsequent discharges, as a result of which the population of possible participants had reduced considerably. This results in a healthy-worker effect; the 'drop-out' population perceived significantly less decision latitude and included more workers with high strain at baseline. Consequently, it is possible that the impact of job stress on mental health in this study was underestimated. In terms of baseline depression symptoms, there was no difference between the 'drop-out' population and others. Within the sample of eligible workers, an acceptable participation rate of 67.2% was reached.

In conclusion, the results of this study confirm that job stress is an independent risk factor for depression symptoms. Stronger associations were found in women. Repeated high job strain was associated with more elevated risk of developing high levels of depression symptoms in both women and men. The role of work and employment in affecting mental health is still not fully understood nor properly managed in relation to the protection and promotion of good mental health in Europe (Cox *et al*, 2004). There is need for increased interest and research in the area of occupational mental health. The main strengths of this study are the prospective design enabling to properly control for the depression outcome at baseline and the assessment of the impact of not only baseline but also repeated job strain.

GENERAL DISCUSSION

Main findings

The importance of the psychosocial work environment, in particular job stress, for workers' health and well-being has been increasingly acknowledged during the last decades. The Job Demand – Control – Support (JDCS) model has been the most influential model in research on the effect of job stress on health and well-being (Karasek, 1979; Karasek & Theorell, 1990).

The general aim of this thesis was to study the perception of psychosocial job stress, based on the JDCS model, in relation to health within the longitudinal Belstress study. The first particular objective was to examine long-term changes in the perception of job characteristics. Perceptions of six Job Content Questionnaire (JCQ) dimensions - the core dimensions job demands, job control and social support, as well as the supplementary scales of physical demands of the job, job insecurity and impact of world market competition (WMC) - were measured on two occasions with a mean time interval of 6.6 years in a sample of 2,490 workers with stable job titles. A statistically significant long-term stability of all JCQ scales was found. As far as the nature and extent of intra-individual changes over time was concerned, the perception of psychological and physical job demands, job control and social support remained relatively stable (modest average increases of approximately 3%), while a substantial increase in feelings of job insecurity and impact of WMC was noted (average increases of 10% and 15.5%). These results are in accordance with the changing nature of the labor market in Western societies over the last decade in terms of increased globalization, an increasing number of precarious jobs and high levels of job insecurity (Goudswaard & Andries, 2000). Economic stressors such as job insecurity are at historically high levels in today's workforce and have important consequences for the individual workers and their families (negative implications for the psychological and physical health and well-being), as well as for organizations and society (decreased job satisfaction and commitment, lower levels of performance, more absenteism) (Probst, 2005).

The second objective was to explore some possible explanatory mechanisms in the alleged relation between job stress and coronary heart disease. In the second phase of the Belstress study, the aim was to go a step further in exploring the relation between job strain and elevated blood pressure (BP), because no convincing evidence for an association with casual measures of BP was found in Belstress I (Pelfrene *et al*,

2002a). Within a subsample of the second Belstress study, job strain was related to 24-hour ambulatory BP measurements. A group of 89 middle-aged male and female workers perceiving high job strain and an equally large group of workers perceiving no high job strain wore an ambulatory BP monitor during 24 hours on a regular working day. Mean ambulatory BP at work, at home and during sleep was significantly higher in workers with high job strain as compared to others. The associations were independent of covariates, including physical activity prior to BP assessments as measured by an activity monitor. The association between high job strain and ambulatory BP in our study was due to the additive effects of job demands and job control; no significant interactions were found. Especially the negative association between ambulatory BP and decision latitude was consistent and independent of covariates. Our results supported the idea that ambulatory measurements of BP are more appropriate than casual assessments to explore associations with job stress. Based on this and other studies, there is convincing evidence for consistent associations between job strain and ambulatory BP. The particular strengths of our study were the relatively large sample size including both men and women, and the proper adjustment for covariates, especially physical activity as measured by an activity monitor.

Besides classical coronary risk factors such as elevated BP, inflammatory and infectious parameters have been put forward as possible intermediate variables linking job stress to elevated risk of coronary heart disease. Within a subsample from the first Belstress study including 892 males free of clinical coronary heart disease, job stress measures were related to biomarkers of chronic inflammation – fibrinogen, C-reactive protein (CRP) and serum amyloid A (SAA) – and infection – chlamydia pneumoniae (CP), helicobacter pylori (HP) and cytomegalovirus (CMV). A negative association was found between job control and plasma fibrinogen concentrations, independent of covariates. Higher social support at work was independently related to an increased risk of positive titers against CMV. Our results showed no relation between job stress and concentrations of CRP and SAA, nor with positive titers against CP and HP. Although we were unable to identify consistent associations between job stress and inflammatory and infectious parameters in this study, which was rather explorative by nature, more research in this field is needed. More in particular, further research is needed including other parameters, such as the proinflammatory cytokine IL-6, in larger samples of both men and women, with prospective study designs to examine possible prolonged or delayed effects, and with multiple assessments of both exposure

variables (to examine the impact of persistent stress) and outcome measures (to overcome the problem of their intra-individual variability).

The third objective was to examine, in a longitudinal perspective, the role of psychosocial job stress in some health outcomes other than cardiovascular disease: musculoskeletal complaints and mental health. The impact of psychosocial factors, both work- and nonwork-related, on the prevalence of low back pain (LBP) after 6.6 years on average was assessed within a sample of 2,556 workers with stable job title. Psychosocial factors constituted non-negligible risks for LBP in our study. Overall, stronger associations were found in men. After adjustment for individual and physical risks, including occasional back pain at baseline, significant associations for LBP in men were found with low decision latitude and low social support at work. Our results provided additional support to the findings linking LBP to psychosocial risk factors. We were able to perform proper adjustments for physical work load. The associations between psychosocial factors and LBP were not essentially confounded by this characteristic.

We described the prospective impact of job stress on the development of depression symptoms. Within a population of 2,139 middle-aged workers free of high depression scores at baseline, job stress increased the risk for developing high levels of depression symptoms after a mean follow-up time of 6.6 years. Stronger associations were found in women. Independent significant associations were found for low decision latitude, high job strain, and isolated strain in women, but not in men. The adjusted association with high job strain in men was borderline significant. Repeated high job strain was associated with more elevated risk of developing high levels of depression symptoms in both women and men. The results of this study confirmed that job stress is an independent risk factor for depression symptoms. Findings like these are important to increase the interest in promoting good mental health at the workplace. The main strengths of this study were the prospective design enabling to properly control for the mental health outcome at baseline and the assessment of the impact of not only baseline but also repeated job strain.

Points of discussion

The Job Demand – Control – Support model

The JDCS model has been the most influential and widely used model in occupational stress research over the last decades. Evidently, it also received quite some criticism. Its simple nature and general use are considered important strengths of the model, but are at the same time sources of criticism. On the whole, the model has shown to be of value in the context of the stress and health studies presented in this thesis. Not only did we find a significant long-term stability of the job stress dimensions of the model, we also have been able to demonstrate their predictive validity.
In general, studies have shown rather inconsistent results with regard to the association between psychological demands and health; decision latitude has been of greater empirical significance in most studies than have psychological demands (Theorell, 2001). The results we presented here are in line with this finding since decision latitude had much higher predictive value than did job demands in our studies. The scale of psychological demands has been criticized for its instability of meaning (its meaning may differ by population group) and its less consistent ability to predict outcomes (Karasek *et al*, 1998).

We examined the interaction effects between job demands and job control in relation to several health outcomes; none of the interaction terms for job strain were statistically significant. The phenomenon of interaction is not clearly defined and has never been worked out completely in the JDCS model (De Jonge & Kompier, 1997). It has been argued that, although true multiplicative interactions have rarely been observed in studies, the use of the two dimensions of demands and decision latitude together have provided better predictions than either one of them alone (Theorell & Karasek, 1996). According to this view, the existence of a multiplicative interaction term is not the primary issue for the model. What matters is that, according to the model, outcomes are predicted by the combination of demands and decision latitude. Already in his original manuscript, Karasek mentioned the difficulty to assess interaction effects statistically (Karasek, 1979). In fact, the model proposes a “relative excess” interaction, where job strain increases with the relative excess of demands over decision latitude. This means there is a joint effect of both demands and decision latitude, which is a sort of interaction that is difficult to distinguish empirically from additive relationships.

Several alternative models have been formulated in response to the JDC(S) model. These models contain an increasing complexity regarding the number of work characteristics included, regarding the specificity of relationships considered (specific work characteristics predict some outcomes but not others) and/or regarding the situational specificity assumed (applicable only to a limited number of similar professions). Within a large cross-sectional dataset representative of the Dutch workforce, seven of these more complex models and the JDCS model were tested (van Veldhoven *et al*, 2005). The authors concluded that the general JDCS model still is a reasonable starting point for modeling the relationship between work characteristics and workers' health and well-being. However, they also suggested that a slight increase in the number of variables included as well as a limited degree of specificity of relationships could be promising to a certain degree.
On the whole, we join in with De Jonge & Kompier (1997) who, after a critical examination of the model, stated that "although there are various relevant comments on the JDCS model, the core structure of the model still holds".

Self-report assessment of job stress

The results presented in this thesis were based on self-report assessments of job stress. The JDCS model has its primary emphasis on an environmental perspective: the organizational structure of work plays the most consistent role in the development of health problems (Karasek & Theorell, 1990). In line with this, although a self-report instrument, the JCQ is based on sociological questionnaire assessment methods that collect valid data on social environments (Karasek *et al*, 1998). As such, the JCQ presumes existence of socially 'objective' environments, so its goal is to gather 'objective' data about work environments. In designing the items of the JCQ, it was attempted to minimize the self-reflective component in the questions. Nonetheless, the subjectivity of perceptions in self-report instruments like the JCQ has been much criticized because self-reports may be biased by personality characteristics. When both exposure and outcome variables are assessed by means of self-report measures, it is commonly assumed that relationships between these variables are inflated due to common method variance. However, Spector (2006) recently suggested that the automatic criticism of self-reports along with the postulation that method alone is sufficient to produce biases have become an urban legend. Based on empirical evidence, features such as social desirability or negative affectivity should not be

considered as general or automatic sources of common method variance when self-reports are used. Furthermore, it has been suggested that the use of self-report measures for both exposure and outcome variables is less problematic when there is a prospective study design (Tennant, 2001; Theorell & Hasselhorn, 2005).

To overcome the problem of bias in self-report data, some more 'objective' measures of job stress have been developed (Karasek *et al*, 1998). With the imputation method, national average scores of job characteristics for a particular job title are imputed to individuals holding that job title. The problem with this method is that large nationally representative survey data have to be available. Also, the method may lead to misclassification because the variance in job characteristics within occupations is not taken into consideration; this is especially problematic regarding the scale of job demands. Another alternative for self-report data is to have job characteristics estimated by means of expert observations. However, there are important practical problems associated with expert ratings: they are very time consuming and costly. Moreover, the reliability of this measurement is correlated with the scale level: it is usually easier to measure characteristics of low-status jobs than of high-status jobs.
In general, the associations of more 'objective' assessments of psychosocial work risks and health outcomes are usually weaker than when subjective measures have been used (Theorell & Hasselhorn, 2005). Nonetheless, in the SHEEP study for instance, both inferred and self-reported measures of low decision latitude were associated with increased risk of a first myocardial infarction (Theorell *et al*, 1998). When comparing objective and subjective assessments of job stress, fairly good agreements have been reported for decision latitude but not so much for psychological job demands (Ostry *et al*, 2001; Theorell & Hasselhorn, 2005).

On the whole, it can be argued that the dichotomy between so-called 'objective' and 'subjective' measures is not very useful, because obviously both methods have their strong and weak points (Kompier, 2005). So there is no point in deciding whether 'objective' or 'subjective' assessment methods are more valid; they supplement each other and are preferably both included in studies (Kristensen, 1995).

Number of job stress exposure assessments

The results presented in the studies regarding ambulatory BP, biomarkers of inflammation / infection and LBP were based on a single assessment of job stress exposure. Use of a single assessment of job stress however, increases the risk of misclassification due to inaccuracy in measurement (Landsbergis *et al*, 2002). As a result of this, the associations reported in these studies are most likely underestimations or at least conservative estimates of the truly existing relationships. In the last study presented in this thesis, repeated exposure to job strain was related to depression symptoms. Workers with repeated high job strain showed the highest incidence of depression symptoms. The impact of high job strain on depression symptoms was considerably larger when the exposure was repeated than when only baseline exposure was taken into account. Thus, multiple measurements result in a more reliable assessment and help avoid large underestimations of the true associations. This was also concluded regarding coronary heart disease in the Whitehall II study (Kivimaki *et al*, 2006a).

Nonetheless, even with the use of two measurements of job characteristics, no information was available on possible changes in job stress during the time lag between the two measurements. Obviously psychosocial work characteristics may have changed during those years, even within the same job title.

To overcome these issues, some methods have been developed that measure lifetime exposure to job stressors. The motivation is that present exposure is not necessarily a good proxy for lifetime exposure. Landsbergis *et al* (2002) developed a 'Work History Questionnaire' that measures job characteristics over the course of a person's working life. The questionnaire is completed by individuals for each past job, which results in a lifetime exposure to job stressors assessment. Another example is the job exposure matrix in which exposure scores are assigned retrospectively to occupations, resulting in individual work organization exposure profiles over the life course (Johnson & Stewart, 1993).

Study population

Participants in the Belstress study were not recruited from a representative sample of the Belgian working population. This however is not likely to pose large problems for the last four papers in this thesis, since the representativeness of study populations is

of little value in analytical studies where possible causal relationships are examined (Kristensen, 1995). In analytical studies, it is the variation of exposure that matters. A substantial variation in exposure to stressors was guaranteed since our study population covered a broad range of companies and occupational groups. In contrast, representativeness of study populations is essential in descriptive studies. Therefore, the results of the first paper regarding long-term changes in the perception of job characteristics should be interpreted with caution. Our findings can not be generalized as such to all workers in Belgium.

The results presented in this thesis were mainly based on observations within relatively large enterprises, as is the case for the majority of occupational health studies in the international literature. It is recommendable that in the future, research on stress and health increasingly focuses on workers from Small to Medium-sized Enterprises. It is plausible that the situation concerning job stress in relation to health is to some extent particular in this population.

An issue which is of significance for the longitudinal studies presented here is the presence of a selection bias in the population. For the second phase of the Belstress study, nine of the original 25 companies were involved. Within these companies, more than half of the original population was no longer available for participation due to decease, chronic disease, retirement, resignation or dismissal. Some companies had undergone major reorganizations with subsequent discharges resulting in a considerable reduction of possible participants. Consequently, a healthy-worker effect was operating with the 'drop-out' population perceiving less job control, more job insecurity and more impact of WMC at baseline. Therefore, we most likely underestimated the increase in feelings of job insecurity and impact of WMC, as well as the relation of job stress with LBP and depressive symptoms.
In the second phase of the Belstress study, an acceptable participation rate of 67.2% was reached. Non-respondents were on average older and lower educated. However, since respondents did not significantly differ from non-respondents in baseline JCQ scores after controlling for age and educational level, no strong indication for a severe selection bias seemed present.

Directions for future research

Finally, we want to discuss some directions for future research. As mentioned before, the JDCS model, although a valuable tool in occupational health research, is not without criticism and should be persistently evaluated and elaborated. Within the JCQ Workshop, a proposal has been worked out to extend the JCQ with some new dimensions (Karasek, 2005). The scale of decision latitude should not be restricted to task level decision latitude, but also include macro-level components such as organizational structural protections, organizational well-being support programs and organizational trust perceptions. Alongside quantitative aspects, the scale of job demands should be extended to comprise emotional and cognitive demands as well.

Another general theory of occupational stress besides the JDCS model is the 'effort-reward imbalance' (ERI) model developed by Siegrist (2001). The model conceptualizes stress as a situation of imbalance, more in particular a combination of high efforts at work (job demands and obligations that are imposed on the workers) and low rewards (in terms of money, esteem and career opportunities including job security). Numerous studies have empirically tested the model in relation to a wide range of health outcomes including cardiovascular disease, behavioral outcomes and psychological well-being (Van Vegchel *et al*, 2005). Overall, the JDCS model offers a broader approach in comparison with the ERI model because it includes both a stress dimension in relation to health as well as a motivation dimension in relation to active behavior and learning. On the other hand, while the JDCS model has its focus on situational characteristics of the work environment, the ERI model includes both situational (extrinsic) and personal (intrinsic) characteristics referring to overcommitment. The focus in the JDCS model is on workplace characteristics, while some components of the ERI model (salaries, career opportunities / job security) are linked to macro-economic labor market conditions. An important direction for future research is to integrate both models into stress and health studies (Bosma *et al*, 1998). Moreover, some studies presented promising results regarding the combined effect of both models on mental distress (Calnan *et al*, 2000) and coronary heart disease (Peter *et al*, 2002). These studies suggested that the prediction of work-related health improves considerably when dimensions of the JDCS and ERI model are combined compared to only one of the models being included.

According to the JDCS model, the cure for job stress lies in the transformation of the organizational structure of the workplace (Karasek & Theorell, 1990). This implies the feasibility of psychosocial job redesign as well as the broader process of work reconstruction. In reality however, despite the considerable knowledge of the etiologic relationship between stressful job conditions and various health outcomes, relatively little is known about effective interventions at the organizational level to prevent stress-related health problems (Hurrell, 2005). Various illustrations of actual interventions have been described in literature, for instance the implementation of a psychosocial educational program for managers (Theorell *et al*, 2001), a web-based health promotion and stress management training (Hasson *et al*, 2005) and the organization of 'health circles' or workplace discussion groups (Aust & Ducki, 2004). On the whole however, primary prevention research is still sparse and provides only limited evidence that certain specific prevention efforts have worked (Hurrell, 2005). The majority of stress interventions focus on reducing the effects (secondary prevention), rather than reducing the presence of stressors at work (primary prevention) (Kompier & Kristensen, 2001). Also, the main target in stress interventions is usually the individual employee rather than the workplace or the organization, and many interventions do not include a systematic risk assessment and are not evaluated in a systematic way.

Nevertheless, although the effects found are rather inconsistent, organizational interventions that focus on changing task characteristics, work conditions or social aspects to reduce stress and improve health have shown their potential to be effective (Semmer, 2006). One should be aware that organizational interventions generally involve an inherent risk of failure; it may not be reasonable to expect positive changes in all indicators of health and in all subgroups. Intervention approaches that target both the person and the work environment and use a participatory approach are likely to be the most promising ones. Other important criteria are a sound problem analysis and management support. So the main challenge for occupational stress research in the future is to effectively transform the impressive existing body of knowledge on stress and health into prevention (Kompier & Kristensen, 2001). At this moment there is still a wide 'science-policy gap': although there is increasing awareness of ways to promote health and well-being at work, there seems to be a long way to go before effective measures are taken (Levi, 2001). Based on the results in this thesis, we recommend that the focus in interventions is put on the enhancement of decision latitude in order to improve work-related health and well-being.

Research on the economics of occupational health has expanded considerably during the last years, with a large increase in studies on the benefits, costs and effectiveness of workplace interventions (Leigh, 2006). Results of these studies are essential for encouraging companies to carry out interventions. On the other hand, the willingness of managers to carry out interventions also depends to a considerable degree on trustful professional relationships with those who propose and conduct interventions (Semmer, 2006). Therefore, efforts should be made to establish professional trust relationships with employers.

Psychosocial well-being of workers has become an essential topic in social policy, as was described in the introduction. The issue of psychosocial risks at work and the prevention of them are now integrated within an official and legal context. On the other hand, the actual implementation by means of particular intervention projects within the specific context of companies depends largely on the commitment of the people involved, for instance within the Services of Prevention and Protection at Work. The realization of specific projects and initiatives within companies should be sufficiently supported by both the management and the workers in order to be successful. Most importantly, projects should not be focused exclusively on the individual. Too often the emphasis in specific intervention projects lies on adjusting the response of workers to stress factors in their working environment. This implicitly places the responsibility with the individual worker; the working environment as such is not questioned. According to the JDCS model though, intervening in the issue of stress at work and its adverse consequences should happen through the transformation of the organizational structure of the working environment. In order to realize this by means of specific projects within companies, it is crucial to lower the gap between science on the one hand and policy and management on the other.

As a final point, in the future, occupational health research should keep on focusing on the impact of adverse work characteristics since these continue to be an unfortunate reality for many workers. Over the last fifteen years, from 1991 to 2005, increasing levels of work intensity have been reported by European employees (European Foundation for the Improvement of Living and Working Conditions, 2006a). Autonomy at work in Europe is relatively high, but it seems to be on the decline. Although the proportion has been consistently declining over the last fifteen years, still one in four workers consider their health and safety to be at risk because of their work. To end with a positive note however, according to the Fourth European Working Conditions Survey

conducted in 2005, the majority of European workers are satisfied with their working conditions; this is linked to job security, a positive working atmosphere and good opportunities to learn and grow (European Foundation for the Improvement of Living and Working Conditions, 2006b).

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SUMMARY

During the last decades, psychosocial well-being of workers, and more in particular the issue of stress at work, has become a significant point of interest on the social policy agenda in most Western societies. Within this context, the introduction of Karasek's (1979) job strain model at the end of the seventies has been of major significance for occupational health research. This "Job Demand – Control" (JDC) model gave impetus to the development of an extensive research tradition and has been the most influential model in studies on the impact of job stress on health and well-being. The job strain model is a two-dimensional model that distinguishes two elements of the work environment: the job demands placed on the worker and the discretion the worker has in deciding how to meet these demands. According to the strain hypothesis, the most adverse reactions of psychological strain occur when the psychological demands of the job are high and the worker's decision latitude in the task is low, which is labeled as high job strain. In a later phase, the original JDC model was extended to include social support at the workplace by supervisors and co-workers as a third dimension: the "Job Demand – Control – Support" (JDCS) model. The iso-strain hypothesis states that workers with high job strain in combination with low social support at work, labeled as 'iso-strain' or 'isolated strain', are most vulnerable to negative health effects. For the purpose of empirically testing the JDCS model, the Job Content Questionnaire (JCQ) was developed as a self-administered instrument with standardized questions that measure elements of the psychosocial work environment.

The general aim of this thesis was to study the perception of psychosocial job stress, based on the JDCS model, in relation to health within the longitudinal Belstress study. BELSTRESS, the Belgian part of the European JACE study, was a large epidemiological cohort study about job stress, cardiovascular and other health issues and sickness absence. The first phase of the study took place from 1994 to 1998 and included a total of 21,419 respondents aged 35-59 years from 25 companies or public administrations across Belgium. Data were gathered through self-administered questionnaires and bio-clinical examinations. The second study phase took place from 2002 to 2004 and involved nine of the original 25 companies or public administrations. All workers who had participated in the first study and who were still at work in the same companies were invited to participate again. A total of 2,821 persons (1,950 men

and 871 women) participated. Data were gathered for a second time through self-administered questionnaires and bio-clinical examinations.

The first particular objective of this thesis was to examine long-term changes in the perception of job characteristics. Perceptions of six JCQ dimensions - the core dimensions job demands, job control and social support, as well as the supplementary scales of physical demands of the job, job insecurity and impact of world market competition (WMC) - were measured on two occasions with a mean time interval of 6.6 years in a sample of 2,490 workers with stable job title (chapter 1). A statistically significant long-term stability of all JCQ scales was found. As far as the nature and extent of intra-individual changes over time was concerned, the perception of psychological and physical job demands, job control and social support remained relatively stable, while a substantial increase in feelings of job insecurity and impact of WMC was noted.

The second objective was to explore some possible explanatory mechanisms in the alleged relation between job stress and coronary heart disease. Within a subsample of the second Belstress study, job strain was related to 24-hour ambulatory blood pressure (BP) measurements (chapter 2). A group of 89 middle-aged male and female workers perceiving high job strain and an equally large number of workers perceiving no high job strain wore an ambulatory BP monitor during 24 hours on a regular working day. Mean ambulatory BP at work, at home and during sleep was significantly higher in workers with high job strain as compared to others. The associations were independent of covariates, including physical activity prior to BP assessments as measured by an activity monitor. Within a subsample from the first Belstress study including 892 males free of clinical coronary heart disease, job stress measures were related to biomarkers of chronic inflammation – fibrinogen, C-reactive protein (CRP) and serum amyloid A (SAA) – and infection – chlamydia pneumoniae (CP), helicobacter pylori (HP) and cytomegalovirus (CMV) (chapter 2). A negative association was found between job control and plasma fibrinogen concentrations, independent of covariates. Higher social support at work was independently related to an increased risk of positive titers against CMV. Our results showed no relation between job stress and concentrations of CRP and SAA, nor with positive titers against CP and HP.

The third objective was to examine, in a longitudinal perspective, the role of psychosocial job stress in some health outcomes other than cardiovascular disease: musculoskeletal complaints and mental health. The impact of psychosocial factors, both work- and nonwork-related, on the prevalence of low back pain (LBP) after 6.6

years on average was assessed within a sample of 2,556 workers with stable job title (chapter 4). Psychosocial factors constituted non-negligible risks for LBP in our study. Stronger associations were found in men. We described the prospective impact of job stress on the development of depression symptoms (chapter 5). Within a population of 2,139 middle-aged workers free of high depression scores at baseline, job stress increased the risk for developing high levels of depression symptoms after a mean follow-up time of 6.6 years. Stronger associations were found in women. Repeated high job strain was associated with more elevated risk of developing high levels of depression symptoms in both women and men.

The JDCS model has been the most influential and widely used model in occupational stress research over the last decades, but also received quite some criticism. Its simple nature and general use are considered as important strengths of the model, but are at the same time sources of criticism. On the whole, the model has shown to be of value in the context of the stress and health studies presented in this thesis. Not only did we find a significant long-term stability of the job stress dimensions of the model, we also have been able to demonstrate their predictive validity. Decision latitude had much higher predictive value than did job demands in our studies, which is in line with findings from numerous other studies. In the future, the JDCS model should be persistently evaluated and elaborated. Another important direction for future research is to effectively transform the impressive existing body of knowledge on stress and health into prevention. At this moment there is still a wide ‘science-policy gap’: although there is increasing awareness of ways to promote health and well-being at work, there seems to be a long way to go before effective measures are taken. Based on the results in this thesis, we recommend that the focus in interventions is put on the enhancement of decision latitude in order to improve work-related health and well-being.

SAMENVATTING

Het psychosociaal welzijn van werknemers, en in het bijzonder het probleem van stress op het werk, is gedurende de laatste decennia een belangrijk aandachtspunt geworden op de beleidsagenda in de meeste Westerse landen. Binnen deze context is de introductie van Karasek's (1979) "job strain" model van bijzondere betekenis geweest voor onderzoek naar de gezondheid van werknemers. Dit "Job Demand – Control" (JDC) model heeft aanzet gegeven tot de ontwikkeling van een uitgebreide onderzoekstraditie en is het meest invloedrijke model geweest in studies over de impact van jobstress op gezondheid en welzijn. Het "job strain" model is een twee-dimensioneel model dat twee elementen binnen de werkomgeving onderscheidt: de werkbelasting die op de werknemer geplaatst wordt en de vrijheid die de werknemer heeft om te beslissen hoe deze werkbelasting moet worden verwezenlijkt. Volgens de "strain hypothese" komen de meest ongunstige reacties van psychologische "strain" of spanning voor wanneer de psychologische belasting van de job hoog is en de beslissingsvrijheid of job controle laag, wat bestempeld wordt als "high job strain". In een latere fase werd het originele JDC model uitgebreid met sociale ondersteuning op het werk vanwege supervisors en collega's als derde dimensie: het "Job Demand – Control – Support" (JDCS) model. De "iso-strain hypothese" stelt dat werknemers met "high job strain" in combinatie met een lage sociale ondersteuning op het werk, zogenaamde "iso-strain" of "isolated strain", het meest kwetsbaar zijn voor negatieve gezondheidseffecten. Om het JDCS model empirisch te kunnen toetsen werd de "Job Content Questionnaire" (JCQ) ontwikkeld als een schriftelijke vragenlijst met een reeks gestandaardiseerde vragen die elementen van de psychosociale werkomgeving meten.

Het algemene doel van deze thesis was het bestuderen van de perceptie van psychosociale jobstress, gebaseerd op het JDCS model, in relatie tot gezondheid binnen de longitudinale Belstress studie. BELSTRESS, het Belgisch aandeel binnen de Europese JACE studie, was een grootschalige epidemiologische cohorte studie over jobstress, cardiovasculaire en andere gezondheidsfactoren, en werkverzuim wegens ziekte. De eerste fase van het onderzoek ging door van 1994 tot 1998 en omvatte een totaal van 21,419 respondenten tussen 35 en 59 jaar uit 25 bedrijven of openbare instellingen in België. De gegevens werden verzameld via schriftelijke vragenlijsten en bioklinische onderzoeken. De tweede onderzoeksfase werd uitgevoerd van 2002 tot 2004 en had betrekking op negen van de oorspronkelijke 25 bedrijven of openbare

instellingen. Alle werknemers die aan de eerste studie hadden deelgenomen en die nog steeds aan het werk waren in dezelfde bedrijven, werden uitgenodigd om opnieuw te participeren. In totaal namen 2,821 personen (1,950 mannen en 871 vrouwen) deel. De gegevens werden voor een tweede keer verzameld via schriftelijke vragenlijsten en bioklinische onderzoeken.

De eerste specifieke doelstelling van deze thesis bestond erin lange termijnveranderingen in de perceptie van job karakteristieken na te gaan. De percepties van zes JCQ dimensies – de kerndimensies psychologische werkbelasting, beslissingsvrijheid en sociale ondersteuning, alsook de aanvullende schalen van fysieke werkbelasting, werkonzekerheid en impact van de wereldmarktcompetitie – werden gemeten op twee gelegenheden met een gemiddeld tijdsinterval van 6.6 jaar in een groep van 2,490 werknemers die in dezelfde job bleven werken (hoofdstuk 1). M.b.t. alle JCQ schalen werd een statistisch significante stabiliteit op lange termijn gevonden. Wat betreft de aard en de grootte van de intra-individuele veranderingen doorheen de tijd, bleef de perceptie van psychologische en fysieke werkbelasting, beslissingsvrijheid en sociale ondersteuning relatief stabiel, terwijl zich een substantiële stijging in gevoelens van werkonzekerheid en impact van de wereldmarktcompetitie voordeed.

De tweede doelstelling was het exploreren van een aantal mogelijke verklarende mechanismen in de veronderstelde relatie tussen jobstress en coronaire hartziekte. “Job strain” werd in verband gebracht met ambulatoire bloeddrukmetingen in een deelpopulatie van de tweede Belstress studie (hoofdstuk 2). Een groep van 89 mannelijke en vrouwelijke werknemers van middelbare leeftijd met “high job strain” en een gelijk aantal werknemers zonder “high job strain” droegen een ambulatoire bloeddrukmeter gedurende 24 uur op een gewone werkdag. De gemiddelde ambulatoire bloeddruk op het werk, thuis en tijdens het slapen was significant hoger bij de werknemers met “high job strain” in vergelijking met de andere groep. De associaties waren onafhankelijk van covariaten, inclusief de fysieke activiteit net voor de bloeddrukmetingen zoals gemeten met een bewegingsmeter. In een subgroep van de eerste Belstress studie met 892 mannen, vrij van coronaire hartziekte, werden jobstress metingen in verband gebracht met biomarkers van inflammatie – fibrinogeen, C-reactief proteïne (CRP) en serum amyloid A (SAA) – en infectie – chlamydia pneumoniae (CP), helicobacter pylori (HP) en cytomegalovirus (CMV) (hoofdstuk 3). Er werd een negatieve associatie gevonden tussen job controle en plasma fibrinogeen concentraties, onafhankelijk van covariaten. Hogere sociale ondersteuning op het werk

was onafhankelijk gerelateerd aan een verhoogd risico op het hebben van positieve titers tegen CMV. Onze resultaten toonden geen relatie tussen jobstress en concentraties van CRP en SAA, en evenmin met het hebben van positieve titers tegen CP en HP.

De derde doelstelling bestond erin psychosociale jobstress in verband te brengen met een aantal andere gezondheidsindicatoren dan cardiovasculaire ziekten in een longitudinale context: musculoskeletale klachten en mentale gezondheid. De impact van psychosociale factoren, zowel op als buiten het werk, op de prevalentie van lage rugpijn na gemiddeld 6.6 jaar werd nagegaan in een groep van 2,556 werknemers die in dezelfde job bleven werken (hoofdstuk 4). Psychosociale factoren vormden ontegensprekelijke risico's voor lage rugpijn in onze studie. Sterkere associaties werden gevonden bij mannen. We beschreven de prospectieve impact van jobstress op de ontwikkeling van depressie symptomen (hoofdstuk 5). Jobstress verhoogde het risico om depressie symptomen te ontwikkelen na een gemiddelde follow-up tijd van 6.6 jaar in een populatie van 2,139 werknemers van middelbare leeftijd die aan het begin van het onderzoek vrij waren van hoge depressiescores. Sterkere associaties werden gevonden bij vrouwen. Een herhaalde meting van "high job strain" was geassocieerd met meer verhoogd risico om depressie symptomen te ontwikkelen bij zowel vrouwen als mannen.

Het JDCS model is gedurende de voorbije decennia het meest invloedrijke en meest gebruikte model geweest in stress onderzoek maar was eveneens onderhevig aan nogal wat kritiek. De eenvoudige structuur en algemene toepasbaarheid worden als belangrijke sterktes van het model beschouwd maar zijn tegelijkertijd bronnen van kritiek. Globaal beschouwd werd de waarde van het model aangetoond binnen de context van de studies naar stress en gezondheid in deze thesis. Niet alleen vonden we een significante lange-termijn stabiliteit van de job stress dimensies in het model, we konden eveneens hun predictieve validiteit aantonen. De dimensie beslissingsvrijheid had een veel hogere predictieve waarde dan werkbelasting in onze studies, wat in de lijn ligt van bevindingen uit talrijke andere studies. In de toekomst moet het JDCS model voortdurend geëvalueerd en verder uitgewerkt worden. Een andere belangrijke richting voor verder onderzoek is het effectief omzetten van de indrukwekkende hoeveelheid kennis die bestaat over stress en gezondheid naar preventie. Op dit ogenblik bestaat er nog steeds een wijde kloof tussen wetenschap en beleid: hoewel er een groeiend bewustzijn bestaat over de wijze waarop gezondheid

en welzijn op het werk bevorderd kunnen worden, lijkt er een lange weg afgelegd te moeten worden vooraleer effectieve maatregelen kunnen worden genomen. Op basis van de resultaten in deze thesis raden we aan om de nadruk in interventies te leggen op de verhoging van de beslissingsvrijheid om zo gezondheid en welzijn op het werk te verbeteren.

DANKWOORD/ACKNOWLEDGEMENTS

Heel wat mensen hebben aan de realisering van dit werk bijgedragen. Zonder hen was dit proefschrift er niet gekomen.

In de eerste plaats wens ik mijn oprechte dank te betuigen aan Prof. Dr. G. De Backer, mijn promotor. U hebt mij van bij het begin, toen ik als pas afgestudeerde aan de vakgroep begon te werken, steeds een grote ondersteuning geboden. Al snel kreeg ik de ruimte en het vertrouwen om mij in het kader van de Belstress studie optimaal te ontplooien in de wereld van het wetenschappelijk onderzoek, maar dat ging steeds met de nodige begeleiding gepaard, wat voor mij een ideale combinatie was. Ik waardeer het uitermate dat ik ondanks uw drukke agenda steeds bij u terecht kon voor vragen. Ik vond het een voorrecht om onder uw toeziend oog aan dit proefschrift te kunnen werken.

Vervolgens gaat mijn uitdrukkelijke dank uit naar Prof. Dr. D. De Bacquer, mijn co-promotor. U was heel nauw betrokken bij de opbouw en afwerking van alle artikels in dit proefschrift. Dirk, bedankt voor alle keren dat ik bij u terecht kon voor de broodnodige methodologische en statistische adviezen en bijsturingen, alsook voor het grondig nalezen van de artikels. Ook toen het soms moeizaam ging, bent u me altijd blijven aanmoedigen, wat ik heel erg waardeer.

Prof. Em. M. Kornitzer bedank ik als lid van de begeleidingscommissie. Vanuit uw ruime deskundigheid en ervaring leverde u bijzonder waardevolle bijdragen aan dit werk.

Graag wens ik de leden van de examencommissie, Prof. Dr. L. Braeckman, Prof. Dr. I. De Bourdeaudhuij, Prof. Dr. J. De Sutter, Prof. Dr. H. De Witte, Prof. Dr. F. Kittel, Prof. Dr. L. Maes en Prof. Em. T. Theorell, te bedanken voor het lezen van dit proefschrift en voor hun constructieve inbreng.

Bedankt aan alle deelnemers van de Belstress studie, alsook aan de contactpersonen binnen de bedrijven en openbare instellingen voor de samenwerking.

Een bijzonder woord van dank gaat uit naar Ruud Mak en Edwin Pelfrène, die ik als mijn mentoren beschouw. Zij zorgden voor mijn vlotte inwijding in de Belstress studie. Ruud en Edwin, het was fijn om op zo een vriendschappelijke manier te kunnen samenwerken, bedankt dat ik in jullie ervaringen mocht delen.

Ik wens de Belstress collega's van de Ecole de Santé Publique aan de ULB uitdrukkelijk te bedanken voor de productieve en aangename samenwerking: Prof. Em. M. Kornitzer, Prof. Dr. F. Kittel, Françoise Leynen en Isabelle Godin. Het was een voorrecht om terecht te komen in een goed draaiend inter-universitair netwerk dat het Belstress team was en nog steeds is. Françoise, het was steeds prettig samenwerken tijdens Belstress II, en op diverse congressen hebben we heel wat boeiende en ook plezierige momenten beleefd, bedankt.

Graag bedank ik Lieve Debruyne, Mia Bellemans en Patrick Vannoote voor hun medewerking aan het veldwerk van de Belstress II studie. Dankzij hen werd van routine onderzoeken een aangename bezigheid gemaakt. Patrick, tijdens de Limburgse uitstapjes werd de basis gelegd van een bijzondere en boeiende vriendschap, waarvoor dank.

Christine Ghysbrecht, heel erg bedankt voor de administratieve en logistieke ondersteuning.

Bedankt aan alle collega's van de Vakgroep Maatschappelijke Gezondheidkunde voor de aangename sfeer in de gangen. Een aantal onder hen bedank ik in het bijzonder voor de vriendschappelijke contacten: Katrien, Sofie, Maaike, Christophe, Isabelle, Anne, Ilse, Ann, Tineke, Charlene, Melissa alsook de ex-collega's Dieter, Lieve, Kelly en Annemie.

Graag bedank ik mijn familie – m'n ouders, broers, schoonzussen en neefjes – en vrienden voor hun steun en interesse.

Tot slot maar zeker niet in het minst gaat mijn dank uit naar Jan en Amélie, de personen waar mijn leven echt om draait, want het leven – of althans zeker het mijne – is gelukkig meer dan jobstress alleen. Jan, bedankt voor alle steun, liefde en de bij

momenten nodige portie verdraagzaamheid en inlevingsvermogen. Lieve Amélie, bedankt voor zoveel vreugde en verrijking!

Els Clays
Juni 2007

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In September 2001 she started working on the BELSTRESS study as a scientific staff member at the Department of Public Health of the Faculty of Medicine and Health Sciences, Ghent University. In November 2006 she joined the assisting academic staff of the Department of Public Health.

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ADDENDUM

Chapter 1

At both Time 1 and Time 2, participants were classified into high or low levels regarding the six JCQ dimensions, based on the median-split procedure. It should be noted that the median-split procedures were identical on Time 1 and Time 2 since the median values of the JCQ dimensions were the same at both observation times. The median value was 30 for job demands, 70 for job control, 23 for social support, 9 for physical job demands, 3 for job insecurity and 6 for impact of WMC.

Chapter 4

On page 81 it was mentioned that “overall, most relationships between psychosocial factors and LBP were not essentially mediated by individual or physical variables”. This should be, however: “overall, most relationships between psychosocial factors and LBP were not essentially *confounded* by individual or physical variables”.

It was mentioned a few times that “nonsignificant increases” were observed. It should be noted, though, that in these cases there is little statistical evidence to justify an increase, given the value of the confidence intervals. On the other hand, the existence of an increase can not be excluded, because the statistical power may be insufficient to show a significant increase.